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Amersham Road, HIGH WYCOMBE, Bucks.
Telegraphic Address: "Zacatecas, High Wycombe."
Telephone: HIGH WYCOMBE 1792 (3 lines).

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Telephone: Colmore 4274-4275 Telegrams: CIRA
The B.C.I.R.A. Scottish Laboratories are:—
Foundry Technical Institute, Meek's Road, Falkirk
Telephone: 332

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The Factory Report

The rather belated appearance of the 1939 Annual Report of the Chief Inspector of Factories detracts but little from its interest, because in the long run it is the relationship between working conditions and industrial legislation which is important. The war temporarily distorts general trends. As the Report covers three months of war conditions, some of these trends are noted, and are not as baneful as might have been expected. The climbing on to roofs in connection with the black-out regulations was responsible for a lengthy casualty list, most of which can be related to the all too common misjudgment of the strength of asbestos sheets. It cannot be too strongly stressed that this asbestos sheeting is much weaker than the materials with which it competes industrially, and those in control of shops which are so roofed must warn anyone whose duty it is to work thereon of the obvious danger. Inevitably, there has also been some increase in accidents by people walking into pillars and posts and the like during the black-out.

There was an increase in the fatalities amongst sand-blasters, though the whole of these cases may not refer to the foundry industry. The total reached 13, the figures for the previous years being 7, 13 and 10. The case is reported of an ironfoundry worker—probably a cupola man—who for the last twenty years has removed the lining of the furnace twice yearly. "Tuberculosis was also present, small foci being scattered throughout both lungs. The histological examination confirmed the presence of silicosis, but it was not of substantial amount. It would appear, therefore, that the dust from the furnace linings was the cause of the degree of silicosis found." As exceedingly few ironfoundry furnaces of any type are lined with silica bricks, high-grade fireclay bricks or rammed monolithic linings being almost universal, this event must remain a State mystery! However, in the case of complete relinings, foundry foremen would do well to see that plenty of water is used to keep down the dust.

The accidents reported under "metal founding" amounted to 10,515 of which 33 were fatal. Among them 1,857 were due to mishaps either with molten metal or corrosive substances; 1,007 to the use of hand tools; 1,393 to being struck by falling bodies; 680 to falls; 614 to stepping on or striking against objects; and 2,904 to handling goods in manufacturing or carrying processes. Of all the preventable accidents the one which, to our mind, is most discreditable, is that listed as being due to falling bodies. It should be borne in mind that the accidents recorded are sufficiently serious as to prevent the injured person from earning any wages for three days. Thus the "falling bodies" are no featherweights. Nor do the figures include accidents ascribable to lifting mechanisms, which are separately listed. Again, the incidence of the "falling body" is no more prevalent in the founding industry than in any other allied sphere of activity. Thus it is difficult not to assess these accidents as being largely preventable by a combination of good housekeeping and well-directed propaganda, and present conditions no doubt would provide some apt material.

Departmental managers should take cognisance of the paragraph dealing with overhead cranes. It appears that the number of preventable fatal and non-fatal accidents has increased. "All too often," the Report states, "it is found that nothing has been done to warn the crane driver that men are at work on or near his crane track. No doubt pressure of work makes it difficult to restrict the use of a crane for any length of time, but it is regrettable that in so many cases proper steps are not taken to ensure that chargemen and workmen know what precautions are obligatory and understand the grave nature of neglect." Usually such paragraphs forecast additional legislation, but in this case the conditions are well covered by Section 24 of the Act.

The section of the Report dealing with hours of employment is exceedingly interesting, as herein is described the influence of war conditions on the arrangement of working hours as expressed by the operatives. Schemes which were accepted as meeting in every way the wishes of the employees are no longer popular. Miss F. Isabel Taylor (the Deputy Chief Inspector), who has been responsible for this section, writes: "Perhaps contrary to expectations, the two eight-hour shift system, as a method of increasing production, has not proved popular. When this has been a possible alternative to long hours on a single shift, the latter has generally been chosen. Similarly, when it has been necessary to work through the twenty-four hours, the two long shifts have proved more popular than the three eight-hour shifts."

D

Warming of Buildings

SOME HISTORICAL NOTES

"The Early Application of Engineering to the Warming of Buildings" was the subject of a Paper which MR. A. F. DUFTON, M.A., presented to the last meeting of the Newcomen Society. In his survey he quoted some interesting conclusions reached over a hundred years ago by Dr. Neil Arnott. Arnott, who was Physician-Extraordinary to Queen Victoria and "probably the greatest sanitarian of his age," was an experimental physicist who turned his attention to the important art of controlling temperature in dwellings for the purposes of health and comfort. He records that, in 1834, that he might have constant motive and better opportunity to observe, to experiment, and to reflect upon the subject, he directed a manufacturer to fit up, in his library, the apparatus for warming by circulating hot water. He was not altogether pleased with the apparatus and, in a general review of the subject, was particularly impressed by the great want, then existing, of an arrangement of fire-place, by which a considerable quantity of fuel, after being lighted, should be caused, without further interference of an attendant, to give out all the heat producible from it, as uniformly at any desired rate, as a candle causes a quantity of grease or wax to give out its light, or as a lamp does the same in regard to a quantity of oil.

It is strange to think that it is now a hundred years since Arnott produced his gravity-fed thermostatically controlled stove and his gravity-fed self-regulating boiler. These were designed for domestic use, and the benefits derived from such appliances can only be appreciated by personal experience.

Objections to Fire-lighting

The stove ordered by Arnott was to be always alight and, in his own words, "This peculiarity, next to the saving of fuel, if not even before it, may be deemed a leading advantage of the stove, from which minor advantages flow. Its importance is perceived by reflecting on the disadvantages of commonly interrupted fires, as—the trouble and expense, with smoke, dust and noise, of lighting the fire every morning at least, and at other times when from carelessness or accident it has been allowed to go out—rooms becoming useless for the time when there is no fire. It is because the stove is ever alight, that the temperature of the place warmed by it is so uniform, and that so much fuel is saved. More fuel is wasted in a common grate during one morning hour, by the attempt made suddenly to raise the temperature of a room which has become cold in the night, than by keeping the fire burning moderately all night."

Arnott has long been neglected but he was quite right, and it is difficult to understand the prejudice against automatic control. Mr. Walker, writing in 1850, remarked that because it required some nicety of adjustment Arnott's regulator was soon abandoned by most of the manufacturers and it is not many years ago that a President of the Institution of Heating and Ventilating Engineers "deprecated in his own practice the elaboration of automatic mechanisms because, in his view, they were not needed and, in the second place, they were liable to get out of order. The usual fate of automatic mechanisms," he averred, "was to be shown for some time with great pride by the proprietor to his guests, but after six months he got tired of them and they were left to rust or rot away without being touched. In normal heating work," he went on, "all that fancy work was not needed."

Nearly all the pioneers in the field of heating have felt the importance of providing healthy, warm buildings for the occupation of the poor and in 1834 Sydney Smirke, in his "Suggestions for the Architectural Improvement of the Western Part of London," records that Mr. Brunel suggested "the practicability of laying on heat to a long range of these dwellings, from one common source, a contrivance which, if perfected, would be of inestimable importance in London, where the high price of fuel is so great a burthen upon the poor."

The author has also an interesting reference to Soho Foundry, Birmingham, and states that Boulton, Watt & Company were responsible for a number of heating installations, and appear to have been the first to use cast-iron pipes for heating. It is of interest that, writing in 1845, Walter Beman made the comment, "In workmanship, modern apparatus is not equal to that erected by Boulton and Watt forty years ago. In this as in other branches of mechanical engineering, the competition or minimum system, that at all times grinds if it should fail to ruin the workman, is most certain in its effect of debasing the quality of his work."

The firm of Boulton, Watt & Company did not employ only the one system for heating buildings but in each case applied the particular method which seemed best adapted to produce the desired effect. Thus Mr. Dufton notes that about 1810 they installed apparatus to warm the Hunterian Museum by means of hot air upon a principle adopted by Mr. Strutt some twenty years earlier to warm his cotton works at Belper near Derby. In this system the air is introduced by means of ducts and upon its way is heated by means of a cockle stove, the cockle being a dome placed over the fire and made either of wrought iron or of rolled iron plates. In warming and ventilating the Infirmary at Derby, Mr. Strutt introduced the fresh air through an underground duct 70 yds. long with an area of 4 sq. ft., so that on cold days the air was appreciably warmed before it was heated by the cockle.

Inspection of Pipe Coatings

The field work of the tests of protective coatings undertaken jointly by the American Petroleum Institute, coating manufacturers, and the National Bureau of Standards has been completed. Only four of the 16 test sites proved to be severely corrosive. Unprotected pipe would apparently last indefinitely in some of the soils. The conductance and pattern tests as well as the condition of the pipe indicate that there is a continual decrease in the effectiveness of most of the coatings tested. The tests indicate that no bituminous or reinforcing material was superior to all others, and the relative effectiveness of most of the coatings was not the same at all sites. At most of the test sites the condition of all of the coated pipe was better than that of the unprotected pipe, but in several instances deeper pits were found on the coated lines than on the adjacent uncoated ones. Although all coatings reduced the total corrosion to some extent and most of them prevented serious pitting at most of the sites during the 10-year period of the test, no coating prevented all corrosion at all test sites. The effectiveness of the coatings was roughly proportional to their thickness, but two coatings of approximately the same thickness sometimes differed considerably in effectiveness.

Catalogue Received

Bolt Fixtures. The Rawlplug Company, Limited, Rawlplug House, Cromwell Road, London, S.W.7, have sent us a photographic chart showing the additions which have recently been made to their line of Rawlbolts. It is available from the Rawlplug Company on request.

Random Shots

Two young metallurgical students had so far progressed in friendship as to discuss their home affairs.

"My old man's a holy terror," said one, "a man of iron will, don't you know. What's your's like?"

"Oh, mine," replied the other, thoughtfully, as if he'd never given the matter consideration before: "I should say mine's a decent old sport. Quite definitely non-ferrous, in fact."

* * *

"Marksman" likes the story of the R.A.F. recruit who, in sending up his barrage balloon, accidentally got carried with it. In spite of the speed with which his mates worked to get the balloon down, it was some while before he was finally deposited on *terra firma*. By this time an ambulance had arrived with doctor and nurses in attendance ready to whisk him to hospital to treat him for shock.

"Go to hospital?" queried the victim incredulously. "No fear! I'm late for the pictures already."

* * *

When a census was taken some time ago of the number of people who sleep in shelters, one warden reported that an old lady he had visited in the top flat of an old house had declared she couldn't possibly sleep in any shelter, public, Anderson, or even the cellar, because she was dead afraid of spiders.

* * *

After painstakingly training a new maid in parlourmaid duties, the mistress thought that she might risk staging a charity bridge party at her house. All seemed to go well: the guests were announced without a hitch, tea was brought in and served quietly, and finally cleared away most efficiently. The hostess was beginning to congratulate herself on the success of the day and her training of the maid when the young woman burst in at the drawing-room door with a dirty jam spoon in her hand, and asked, "Please, marm, will you lick the spoon or shall I?"

* * *

"If the aluminium pan gets burnt," reads a domestic note in the "Stantonian Magazine," "water should be poured into the pot and a small onion added. Then heat the pan until the water boils, and you will find that the burnt matter will rise to the top." But "Marksman" declares that this is no new idea. His cook has been doing it for years; only she sends it to the table labelled "onion soup."

* * *

"German coke reported sold on the Pacific Coast." Such is the amazing announcement in a paragraph from an American contemporary. However, the anti-climax comes when one reads in the article that the coke is being sold by the Canadian Government, being German cargo seized in the Pacific by British men-of-war.

* * *

Definition of a Famous Man.

One whose obituary notice is not simultaneously his obliterary notice.

* * *

This week's foundry crossword clue comes from "The Times."

Clue—How they put the weight in the foundry. *Answer*—Cast iron.

"MARKSMAN."

An American Diary

We thank the Titanium Alloy Manufacturing Company, of Niagara Falls, for sending to us, through their British agents, T. Rowlands & Company, Limited, Broomhall Street, Sheffield, a week-to-the-page vest-pocket diary. It contains a wealth of technical and statistical data of unusual interest.

Permanent Moulds and their Application to the Production of Non-Ferrous Castings*

By FRANK HUDSON

It is interesting to try to visualise exactly what constitutes a permanent mould. In the true sense of the word there is, of course, no such thing. The designation "long-life mould" is obviously more appropriate, but by virtue of common usage the term "permanent" has been applied to any type of mould from which a number of castings may be produced. Probably the most obvious application of this type of mould to the production of non-ferrous alloys is the ordinary ingot mould, made of cast iron or copper, used for the casting of sometimes large but relatively simple shapes. Another familiar example which readily comes to mind is the manufacture of die-castings where the mass of the casting is relatively small but often intricate. In both these examples mass production is a common entity, but whereas in the first case casting composition, and consequently melting point, play a minor part, in the second case these factors at present largely determine whether manufacture is a practical proposition or not.

In between these two extremes, ingot production on the one hand, and the manufacture of die-castings on the other, falls the bulk of ordinary non-ferrous foundry requirements in which the use of long-life moulds has, in this country at any rate, received relatively little application. What possibilities exist in this direction? The answer to this question might conceivably be assisted, first of all, by briefly reviewing the developments which have already taken place here and in other parts of the world.

Development of Long-Life Moulds

In the first place it is of interest to note that in all probability long-life moulds pre-date sand moulds by several thousand years. The progression appears to have been: Stone, hard-burned clay and bronze moulds for the casting of spear heads and kindred articles from copper and its alloys. Naturally, cast-iron moulds are of much later date and their use, principally for ingoting purposes, can probably be traced to about the middle of the 14th century. It was not, however, until the close of the 19th century when die-castings were first developed that any real impetus was given to the question of long-life moulds for casting purposes.

The production of light alloy articles such as pistons, cylinder heads and covers, etc., for the automobile industry, from cast-iron moulds is an outstanding example of the progress made in this direction. At this juncture, it should be pointed out that there is a distinct tendency in some circles to class the method of production just mentioned as gravity die-casting. From the foundry point of view this is not strictly correct, and it is difficult to visualise, say, a large diesel-engine piston about 3 ft. high and 18 in. in diameter as a die-casting even although it is made in a cast-iron or steel mould. These are essentially permanent or long-life mould castings and as such are distinct from die-castings. This point is not sufficiently well appreciated by foundrymen and engineers, and it is worth noting the published remarks of American experience[1] in this direction:—

> "In the first place the cast-iron moulds can be made from wooden patterns and the finishing cost therefore is low. They need not be made from the highest-grade die steels and machined from the solid blank, as is necessary for die-casting dies. The principal advantage of the long-life mould technique, however, is not the lessened die cost, but the fact that no air bubbles or gases are entrapped. Hence the chilling effect of the metal mould produces a dense homogeneous metal that is at least 20 per cent. stronger than a die-casting."

According to the same source of information, the American writer further states that, because of their superior qualities, permanent-mould castings are usurping the field of aluminium die-castings and are being increasingly employed for such articles as washing machine agitators, vacuum cleaners, automatic vending machines, electric ironers, typewriters, aircraft parts and many other machine elements.

Following the production of light alloy articles in permanent moulds, further developments have taken place in an attempt to obtain castings of greater strength, and a considerable measure of success has arisen in this direction by the use of aluminium bronze. Gearbox selector-forks, roller-bearing cages, nuts and bolts and small gear wheels are only a few of the many articles made to-day in this way.

Mention should also be made of the now long-established practice of casting phosphor bronze in stationary permanent moulds, resulting in the production of chill-cast solid and cored sticks so widely used for bearing purposes, valve guides, etc., and by the more modern centrifugal methods developed for liners and gear blanks.

It will be noted that up to this point the production of non-ferrous castings in permanent moulds has been successfully accomplished with certain types of alloys which seem to lend themselves to service with metallic moulds. Surprisingly little work has been done relative to the production of castings in refractory or refractory-lined moulds or in the use of the more common copper-base non-ferrous alloys, so widely employed in the average brass foundry. It may be that there is a production field open in this direction, and a useful purpose may be served by examining the latter problem in some detail. Such is the aim of this Paper.

Mould and Metal Relations

In the manufacture of castings from permanent or long-life moulds there are two broad factors which must be taken into account, apart from the very obvious initial question of design. Consideration might be given in the first place to the effect of the mould upon the metal and, secondly, to the converse—the effect of the metal on the mould.

Effect of the Mould upon the Metal

This aspect has considerably more bearing on the subject than first thoughts indicate, and its importance may be more clearly gauged by recounting a recent experience of some interest. At the present time the demand for rolled phosphor-bronze bars up to 2 in. dia. to B.S. Specification 369/1940, calling for a maximum strength of between 30 and 40 tons per sq. in., with not less than 15 per cent. elongation, exceeds the sources of supply, and a useful purpose would be served if some cast substitute could be developed of similar type and properties. The material possessing the most likely commercial possibilities in this direction appeared to be one of the more recently developed age-hardening bronzes, namely, that containing 88 copper, 5 nickel, 5 tin and 2 per cent. zinc.

This cast alloy, after suitable heat-treatment, compares most favourably with rolled phosphor bronze so far as mechanical properties are concerned, as will be observed from Table I, and it has also a similar structure. Furthermore, no undue difficulty had been previously experienced in the production of sound sand castings, and little initial apprehension existed relative to the scheme finally devised to utilise cast-iron permanent moulds as being the most economical foundry method for the manufacture of 28-in. bars in diameters varying from about $\frac{1}{8}$ in. up to 3 in.

Centre Porosity Defect

Preliminary trials, however, proved disappointing, as bars of the alloy in question cast in this way suffered from slight centre porosity practically along their entire length. Now porosity, however slight, inhibits age-hardening and prevents the necessary mechanical properties being obtained following heat-treatment. The cause of this porosity seemed to be due to the rapid cooling effect of the mould, in conjunction with lack of fluidity in the metal which prevented the necessary degree of feeding taking place. Similar trouble can be experienced in the chill casting of 88:10:2 gunmetal bars to B.S. Specification 382-3/1940 when the presence of centre porosity causes the founder some difficulty in meeting test requirements. Parenthetically, it may be observed that, partially due to this, founders who chill test-bars will find the mechanical properties as specified for 88:10:2 chill-cast bars are actually less than for sand castings. This difficulty is minimised by pouring the moulds through a jet runner between $\frac{1}{4}$ and $\frac{1}{2}$ in. in diameter, according to the size of sticks being produced, in an endeavour to obtain instantaneous solidification throughout the section. The adoption of this method did not, however, eliminate the centre porosity in the 88:5:5:2 nickel bronze. Other expedients were tried without any real measure of success. For example, it is known that bronzes containing over 1 per cent. phosphorus are free from centre porosity when chill cast, due to their extreme fluidity and wide freezing range. Accordingly, steps were taken to increase the fluidity of the nickel bronze by the use of hot moulds, by the use of higher pouring temperatures and even by altering composition so far as this permitted without completely upsetting the final mechanical properties obtained on age-hardening. None of these modifications eliminated the trouble, and satisfactory results were only positively obtained after the adoption of centrifugal casting methods.

This incident clearly indicates that the material used for the permanent mould plays an important part in the production of sound castings. Moulds which cool the casting rapidly (*e.g.*, cast iron, silicon carbide, etc.) are likely to produce better castings both as regards density and mechanical properties when used with alloys having the common entity of adequate fluidity, and in addition a very wide low-temperature freezing range, or in the absence of this, a low order of liquid shrinkage. A wide freezing range will obviously assist feeding under conditions of rapid chilling, whilst there will be no need for feeding in the absence of liquid shrinkage. Very few of the copper-base alloys used in the non-ferrous foundry have these properties.

Cast Phosphor-Bronze Sticks

Phosphor bronze containing 10 per cent. tin and between 0.5 and 1.0 per cent. phosphorus has a wide freezing range, and will produce

* Paper read before the East Midlands Branch of the Institute of British Foundrymen.

chill-cast sticks entirely free from porosity. Furthermore, as will be observed from Table I, rapid chilling promotes maximum mechanical properties. If the freezing range be reduced by decreasing the phosphorus content, centre porosity on rapidly cooled bars becomes evident by the decrease in strength, and slower cooling methods must accordingly be adopted. In addition to the presence of centre porosity, rapid cooling of bronzes containing around 10 per cent. tin leads to the formation of excessive delta constituent, which further reduces strength and ductility. This can, however, be corrected by annealing.

Some idea of alloys in the other category, those possessing a low order of liquid shrinkage, can be obtained from Table II. It will be observed that aluminium bronze and manganese bronze are possibles in this direction, which tends to bear out practical experience, as both these materials are not readily affected by fairly wide variation in cooling rates. It should also be clearly understood at this point that the remarks just made apply to castings of even section made *entirely* in a permanent mould having pronounced chilling effect. They do not necessarily apply to castings which are only partially chilled or of variable section.

Under conditions of slowest cooling, such as would arise when using the ordinary refractory type of permanent mould, alloys having a very wide freezing range such as the bronze containing 1 per cent. phosphorus should be avoided for obvious reasons. Apart from this exception all the more common copper-base materials can probably be safely employed providing the usual precautions are taken in regard to contraction and the provision of adequate runners and risers. In fact, conditions are similar to dry-sand practice, with the exception that the mould is designed to produce several castings instead of one.

TABLE I.—*Effect of Mould upon Mechanical Properties of Some Cast Non-Ferrous Alloys.*

Alloy.	Chill cast.		Sand cast.		Remarks.
	M.S. Tons per sq. in.	E. Per cent.	M.S. Tons per sq. in.	E. Per cent.	
Phosphor bronze (10.5 per cent. Sn, 1.0 per cent. P)	20.7	1.5	15.0	4.5	It is essential to cool this alloy rapidly if satisfactory results are to be obtained. Slow cooling is detrimental.
Gear bronze (11.5 per cent. Sn, 1.5 per cent. Ni, 0.05 per cent. P)	14.0	1.5	24.6	19.8	Rapid cooling is detrimental unless assisted by centrifugal action. Slower cooling as obtained from sand or partially-chilled moulds is to be preferred.
Gunmetal (88:10:2)	15.0	6.5	19.0	25.0	
Nickel bronze (5 per cent. Ni, 5 per cent. Sn, 2 per cent. Zn)—heat-treated	23.4	5.0	34.2	18.0	
Heat-treated (centrifugally cast)	31.6	17.0	—	—	
Brass (44 per cent. Zn, 1 per cent. Sn)	21.0	25.0	16.0	25.0	Rapid cooling gives best results.
Aluminium bronze—					
8 per cent. Al	26.2	48.0	24.9	48.5	Cooling rate within wide limits has little effect on properties.
9.3 per cent. Al	27.8	21.0	30.2	31.0	
Manganese bronze—					
Ordinary	30.0	28.0	28.0	25.0	
High tensile	44.0	25.0	42.8	23.5	

NOTE.—Chill-cast test-bars machined from vertical cast sticks 1 to 2 in. dia. with exception of centrifugally cast nickel bronze.

TABLE II.—*Liquid and Solid Contraction of Some Non-Ferrous Alloys.*

Alloy.	Shrinkage (volume per cent.).	
	Liquid.	Solid.
Aluminium alloy (11.0–13.0 per cent. silicon)	3.5	—
Copper (deoxidised)	3.8	6.9
Aluminium bronze (90 per cent. copper, 10 per cent. aluminium) ..	4.1	7.1
Manganese bronze (40 per cent. zinc, 1.25 per cent. iron, 1 per cent. aluminium, 0.5 per cent. manganese, 0.5 per cent. tin)	4.6	6.9
Nickel silver (20 per cent. nickel, 15 per cent. zinc, 65 per cent. copper)	5.5	6.6
Nickel (98 per cent. nickel, 1.5 per cent. silicon, 0.1 per cent. carbon)	6.1	8.1
Monel (1 per cent. silicon)	6.3	7.6
Gunmetal (5 per cent. tin, 5 per cent. zinc, 5 per cent. lead)	6.3	4.3
Yellow brass (27 per cent. zinc, 2 per cent. lead, 1 per cent. tin) ..	6.4	6.0
Nickel silver (20 per cent. nickel, 15 per cent. zinc, 4 per cent. tin, 5 per cent. lead)	6.5	5.6
Aluminium-rich alloys not containing silicon	6.5–8.0	—
Bearing bronze (10 per cent. tin, 10 per cent. lead)	7.3	3.9

Design of Mould

In between these two extremes a good deal of ingenuity can be displayed in designing the best type of permanent mould to regulate cooling conditions best suited for any particular casting or alloy. For example, the chilling effect of a cast-iron mould could be reduced to promote better feeding of the casting made in it by decreasing the thickness of the mould wall or by the use of a refractory coating, such as is employed in the Holley permanent-mould process for the production of grey iron castings. Very often, too, the application of refractory inserts or cores to a metal mould, or alternatively the inclusion of a chilling insert to a refractory mould, is all that is required to obtain satisfactory results. These modifications obviously depend to a great extent on the design of casting being made, and in view of the variety in this direction it is impossible to do justice to this aspect in the space available on this occasion. It might, however, be mentioned that according to the experience gained in the light castings industry, where sections tend to be light, there is something to be said for the employment of the thinnest possible metal mould section for the majority of alloys in order to prevent excessive chilling which, of course, makes the molten metal sluggish. Frequently in the production of light aluminium castings, an auxiliary heating agent has to be employed on the mould, generally in the form of gas jets, in order to assist fluidity. Furthermore, by proper design of the mould, it is nearly always possible to obtain progressive solidification of the casting being made, which is a distinct asset in many cases.

Effect of the Metal on the Mould

Coming now to the second factor—effect of the metal on the mould—it can be assumed that cast iron and various kinds of refractories are the principal materials of interest. Owing to the relatively high temperatures involved, the casting of copper-base alloys ultimately causes failure of cast-iron permanent moulds through cracking or surface "crazing," so the life of these is limited. The composition of the iron used for the mould, together with the composition and design of the casting being made, has an important effect on the life obtainable. For general purposes a low-phosphorus cast iron having a composition as shown at A in Table III is usually employed. For very massive methods it is desirable to use a hematite-type base iron, high in total carbon in order to get some degree of resilience as shown at B. In this latter type, freedom from premature cracking and crazing may be obtained by adding 1.5 to 1.7 per cent. nickel with 0.4 to 0.6 per cent. chromium. For special work, *i.e.*, moulds for centrifugal casting machines, requiring high strength combined with good thermal shock and heat-resistance, the use of composition C, which contains molybdenum as well as nickel and chromium, is to be preferred.

TABLE III.—*Composition Employed for Cast-Iron Permanent Moulds.*

Element. Per cent.	A.	B.	C.
T.C ..	3.0–3.3	3.5–3.7	2.8–3.0
Si	1.2–1.6*	1.2–1.6*	1.6–2.0*
Mn	0.8–1.2	0.8–1.2	0.8–1.2
P	0.30 max.	0.30 max.	0.20 max.
S	0.12 max.	0.12 max.	0.12 max.
Ni	—	1.5–1.7	2.5–3.0
Cr	—	0.4–0.6	0.5–0.7
Mo	—	—	0.6–0.8

* According to sectional thickness.

In addition to thermal stress and high temperatures, the cast iron used for moulds has also to withstand attack by molten metal, the extent of which is determined by the alloy used. The aluminium oxide film, for example, so readily formed on the surface of molten aluminium bronze affords a large measure of protection to the cast-iron mould, a fact which is mainly responsible for the high position which this alloy occupies in connection with permanent-mould castings. Accordingly, the life of moulds when casting aluminium bronze is greater than that obtained with straight manganese bronze and brasses. It might be presumed that the use of a heat- and corrosion-resisting cast iron, such as Ni-Resist, would have possibilities for permanent-mould work. Whilst such material is probably more resistant to crazing, as shown by Fig. 1, it must not be forgotten that austenitic cast iron has a very high coefficient of expansion which is liable to lead to the development of excessive thermal stresses in many instances and consequent liability to cracking

Mould Dressings

The use of a suitable dressing also materially assists in protecting the mould face. For simple castings made in open moulds such as ingots, sticks, etc., a paste made from rape or lard oil with finely ground plumbago has reliable qualities, and ordinary blacklead grate polish makes a good substitute. For more intricate

work in closed or centrifugal moulds very great care must be taken to see that the dressing is not too "gassy," and a plain rub with plumbago is to be preferred. In practice an attempt is made to keep the mould at a temperature usually between 200 and 250 deg. C.

Any cores that may be required for castings made in iron moulds can be of the ordinary sand type or where design permits of carbon, low-alloy or heat-resisting steel. In the majority of cases, the cheaper steels are employed except where the cores are small and apt to become overheated, when the use of heat-resisting steel becomes essential. The life of a cast-iron mould on non-ferrous work will vary considerably, according to the size, design and composition of the articles being made, and may be anything up to 10,000 castings.

The idea of making refractory moulds which can be used for more than one casting has long occupied the minds of many practical foundrymen, and there has been no lack of attempts in this direction. In 1928 particulars were given in THE FOUNDRY TRADE JOURNAL[2] of the Büsselmann process developed in Germany for the production of grey iron castings, when it was claimed that by its use in the manufacture of large columns 33⅓ per cent. was saved on moulding time and 25 to 30 castings were repeatedly secured from one mould. The material used for the long-life mould was approximately:—2 parts ground fireclay; 2 parts china clay; 1 part coke; 3 parts silica sand; 4 parts high-quality moulding sand; 3 parts clay water. These materials were ground and mixed in a pan mill to a ramming consistency with the addition of extra moisture if necessary. It was also pointed out that by the addition of 2 to 4 parts of asbestos fibre the permanence of the resulting mould could be increased by 20 to 25 per cent.

There is nothing original about this particular mixture, and it has been quoted primarily to illustrate the point that a fireclay mould has been successfully used for the production of more than one casting. The fact that iron castings were produced in this particular instance does not matter very much, as such a mould will obviously work equally well with non-ferrous material like gunmetal, etc., if due allowance be made for the difference in contraction between the two metals. It is, however, of great importance to remember that such a mould—and this applies to all refractory materials used for this purpose—must be handled gently both by men and metal. One appreciates that moulds of this type cannot be thrown about, but it is often forgotten that the stresses imposed upon the mould by the metal are liable to do just as much damage. Accordingly provision must be made for the contraction of the casting to be either taken up by some softer material than the mould, or to get it out of the mould before contraction commences.

It must also be emphasised that very thorough drying of fireclay long-life moulds at the highest possible temperature before use is of very great importance. This is required not only to remove moisture but to ensure that any volume change likely to arise on heating is developed throughout the mould, rather than to have a large differential volume change occur following contact with molten metal during the casting operation. In many instances, the high temperature required to stabilise the ordinary fireclay mould is beyond the capabilities of most foundries, but this can be overcome by using a refractory base which has already been stabilised, such as sillimanite or crushed old firebricks.

A permanent mould mixture made from either of these materials bonded with 3 to 5 per cent. sodium silicate is not only more resistant to thermal changes than fireclay mixtures but is also much stronger after drying. Such a mixture has not a high green-bond strength and accordingly requires a certain amount of care to be taken during moulding. It rapidly air-hardens, however, in a warm atmosphere and patterns can usually be drawn, if the freshly rammed mould is allowed to stand for some time. Alternatively gaggers or nails can be conveniently employed to reinforce weak or thin sections. The addition of a bonding material such as clay is not recommended. Old newspaper is the best parting medium.

All the silica-base, long-life mould materials have poor thermal conductivity and therefore do not exert much chilling effect on the casting. This can, however, be readily overcome by the use of a silicon-carbide mixture as previously suggested by the author.[3] In fact it is quite a practical proposition to employ a composite mould, using silicon carbide where chilling is required and a base of crushed firebricks elsewhere.

Suitable dressings for such refractory moulds comprise a mixture of plumbago with water to which has been added just enough sodium silicate or core gum to make it adhere to the mould. Application should be by means of a spray. If core gum be employed for bonding purposes, the mould should be dry-brushed and redressed after each cast. The mixture utilising sodium silicate is more permanent and will last two or three casts before renewal. It is inclined, however, to "build-up" and become patchy if care is not taken. Alternatively a coating of soot deposited by means of an acetylene flame can be employed.

(*Continued on page* 158.)

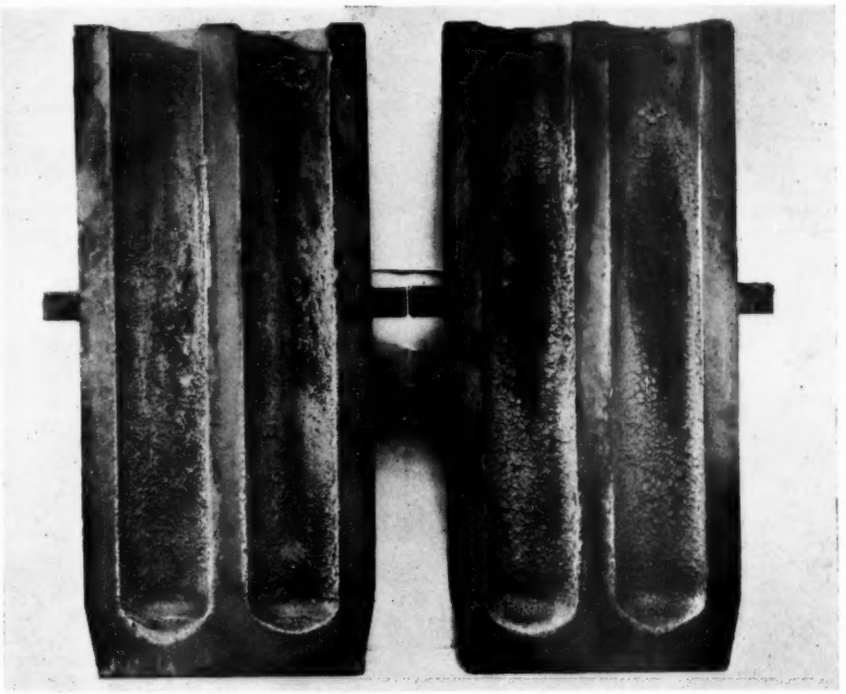


FIG. 1.—APPEARANCE OF "NI-RESIST" (LEFT) AND ORDINARY GREY IRON (RIGHT) HALF-MOULDS AFTER USE ON MANGANESE-BRONZE INGOT PRODUCTION.

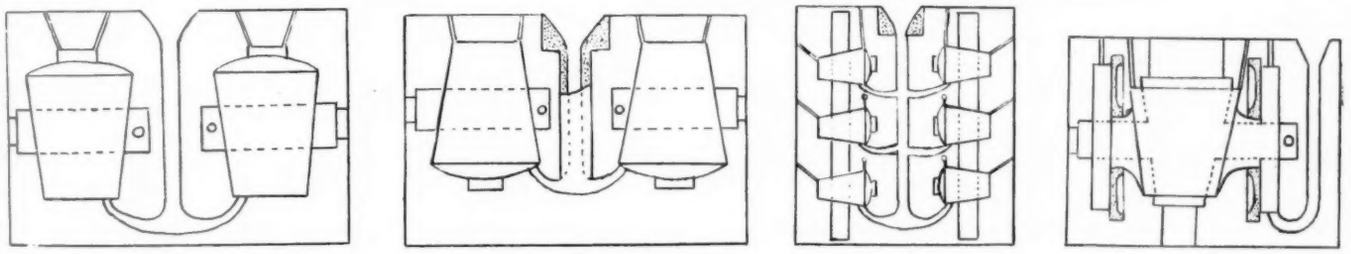


FIG. 2.—POSSIBLE DESIGNS OF PERMANENT MOULDS FOR GUNMETAL CASTINGS.

A—Plugs for Cocks. (Medium and Large.) Bad design. Runner restricts contraction of the casting and runner and ingates are too long.

B—Plugs for Cocks. (Medium and Large.) Better design. No restriction on casting contraction. Runner and ingates short. Runner formed by renewable oil-sand or soft dry-sand bush, which enables hot metal to reach castings and permits free contraction of runner.

C—Plugs for Cocks. (Small.) Suggested method of making small plugs.

D—Plug Cock. Note collapsible cores to assist inward flange contraction. It may also prove advantageous to bush runner as in B.

Incendiary Bombs

METHODS OF DETECTING THEIR ARRIVAL AND LOCATION

A memorandum, "Fire-Detection Devices, with Special Reference to the Detection of Incendiary Bombs," has been published by the Institution of Electrical Engineers in the form of a report by the I.E.E. Advisory Committee to the Ministry of Home Security, and in view of the interest attaching to the subject just now, we append a few extracts.

The earliest indications of the arrival of an incendiary bomb are, in general:—(*a*) The effect of impact; (*b*) the noise of the impact as the bomb hits a roof or other obstruction; and (*c*) the light produced as the bomb starts to function. It therefore seems logical that any system specially devised for the detection of incendiary bombs would in effect be a sound detector or a light detector, or a device depending for its operation on the force of impact. Such devices may be regarded as detectors of the arrival of an incendiary bomb.

Subsequent indications of the presence of an incendiary bomb are the results of heat or fire. As at present developed, the well-known appliances for fire detection would, in general, detect the fire caused by an incendiary bomb rather than the presence of the bomb itself, but adaptations of the schemes may be possible whereby the detector operates by virtue of the heat given out by the bomb itself in the very early stages of its combustion.

The type of bomb mainly under consideration in this memorandum is the 1-kg. magnesium bomb, which has a light output of about 6,000 c.p. and a heat output of about 15,000 B.Th.U.

Any detector which indicates in any way the presence of light or fire can be made to operate, either mechanically or electrically, an alarm or signal device such as an electric bell located in a shelter, control point or other place where some person is in attendance. These detectors can in many instances operate fire-extinguishing devices as well as alarms.

Impact Detectors.—Many forms of impact detectors can be envisaged, and a scheme which has been installed in a building in London makes use of a strong hemp net held under the roof on springs or elastic. Cords are attached to the edges of the net and are taken to pairs of contacts, which are fixed about 12 ft. apart round the roof space. These cords pass through a metal eye which is screwed into the wall, and to the free end of the cord is attached a metal ring or washer of such a size that when the cord is pulled by depressing the net, the ring will make contact with the eye, but will not pass through it. The eye and ring are tinned and immediately they come into contact, an electric bell is rung. In another form of impact detector two layers of wire netting are suspended over the space to be protected, the layers being, say, 2 in. apart. The impact of a falling bomb causes an electrical circuit to be closed by the two layers of netting coming into contact. Another system comprises a mesh of series circuits made up of insulated wires connected in such a manner that an interruption in any part of the circuit will cause a signal to be given.

These systems suffer from the great disadvantage of requiring quantities of materials which, particularly in the case of wire netting, are urgently required for other purposes, but ingenuity may devise methods using materials more readily available.

Light Detectors.—Of the various means of detecting the arrival of an incendiary bomb, those depending on the action of the light emitted as soon as the bomb ignites would at first sight seem likely to prove suitable for giving an immediate signal with a minimum of false alarms. These detectors consist essentially of photo-electric or selenium cells arranged to respond immediately to an increase in the light falling upon them.

Fire Detectors.—There are two main classes of fire detectors, namely, those depending on the presence of smoke and those depending on the generation of heat. A further class depends on the use of radio-active materials. The majority of the well-known fire-detection systems used in buildings are of the type which depends on the effect of temperature. Devices more recently developed depend on the destruction of thin material by oxidation or flame. In both cases practically all of them use electrical means for operating the alarm. A system depending on the destruction of material by flame or contact with smouldering matter consists of a paper strip incorporating a narrow metallic strip of low melting point connected to a battery and a relay. The strip forms a continuous circuit through which current from a dry cell is passed. The strip is connected to an alarm panel and the breaking of the circuit by the burning of the strip operates a relay and sounds an alarm.

There are several well-established systems for the detection of smoke at a very early stage of its development. In general, the atmosphere in the space to be protected is continuously sampled by being drawn through small-bore tubing into a centralised cabinet. A beam of light, either deflected by the smoke particles or dimmed by them, is utilised to operate an alarm through a photo-electric cell. The apparatus is comparatively expensive, however, and its installation in an existing building involves a good deal of work.

Maintenance

Whatever system may be adopted, it is essential that all the component parts be efficiently maintained and, to ensure this, periodic tests should be carried out. For the larger installations put in by specialist firms a servicing arrangement may be agreed for maintenance.

From this point of view there is some advantage in "closed circuit" systems, since a defect in the wiring, etc., automatically calls attention to itself by operating the alarm. These systems, however, and other systems using valve amplifiers, require a continuous flow of current, which may impose too heavy a drain on batteries alone, so that a mains supply is generally necessary in order to conserve battery charging or replacement, a battery being retained as a standby in case of failure of the mains supply. All wiring should be properly installed and protected and, in order to minimise disruption as much as possible from other bomb damage, circuit runs should be widely dispersed. In this connection it may be an advantage in some instances to use local bells and eliminate long wiring runs, provided the bells ring loudly enough to be heard where action can be initiated to deal with the alarm.

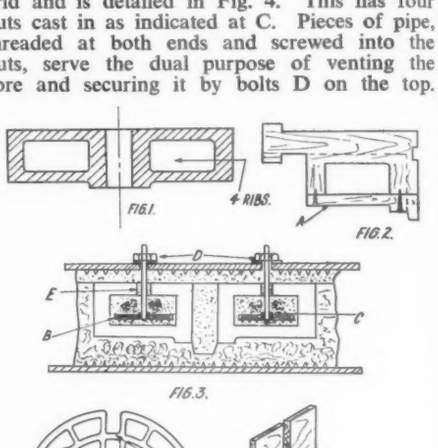
British Standard for Engineers' Squares

The British Standard Institution will shortly issue a further Specification in the series of British Standards for engineers' precision tools, namely for engineers' steel squares, which has also been prepared with the co-operation of the manufacturers and in close collaboration with the National Physical Laboratory. In this specification provision is made for squares of three grades of accuracy, namely, reference, inspection and workshop. Squares in the first grade serve for reference purposes, where the highest degree of accuracy is essential; those in the second grade are for inspection purposes or for use in tool rooms and workshops where a good grade of accuracy is necessary; those in the last grade are for general workshop use. Copies of this Standard No. 939 will be available from the Institution, 28, Victoria Street, London, S.W.1. (Price 2s. 3d. post free.)

Some Jobbing Foundry Experiences—XIX

By "TRAMP"

A typical piston of the box type that can conveniently be made by loam sweeps is shown in Fig. 1. The casting is strengthened by four ribs, and it is necessary to cast four holes through one side of the piston to support and vent the core, and also to permit its subsequent removal, together with the cast-iron grid used to support it. This grid has to be broken before it can be removed, and consequently it must be of light section. The holes through the casting are plugged previous to finish-machining. The mould is swept by the board in Fig. 2. Piece A being removed, the same board is used to sweep the core. A section of the finished mould (Fig. 3) illustrates the method adopted to strengthen the core and to hold it in position during casting. B is the cast-iron grid and is detailed in Fig. 4. This has four nuts cast in as indicated at C. Pieces of pipe, threaded at both ends and screwed into the nuts, serve the dual purpose of venting the core and securing it by bolts D on the top.



The grid is made in one piece, being connected at F. This makes the core more rigid but necessitates the arms being cut away as shown in Fig. 5. The method of building the core is as follows: Having swept a true bed and allowed it to stiffen, loam is applied over this and the grid bedded in. The four arms are set in place and pieces of dried loam are used to form the exterior shapes; the interior is filled with cinders. Loam is applied to the outside and top of the core and struck off by the board. Spaces are kept open around the nuts and the tubes screwed in after the removal of the board. After drying, the core is lifted by two hooks (also cast in the grid), blackwashed and placed in the mould on pieces of wood of the required thickness. Four small cores E are secured in the correct position. A plain cope with suitable holes through to accommodate the projecting tubes is lowered in place and the core bolted to it. The top is then lifted and the wood removed. The centre core is inserted and the cope returned to place and the job made ready for casting.

Abrasive Grain Sizes

The U.S. Bureau of Mines has issued a simplified practice recommendation (R118-40) on "Abrasive Grain Sizes." This recommendation covers a simplified schedule of grain sizes for aluminium-oxide and silicon-carbide abrasives for polishing uses and for grinding wheel manufacture. Copies of the recommendation may be obtained from the Superintendent of Documents, Government Printing Office, Washington (price 5 cents).

Cast-Iron Electrodes for Welding Grey Cast Iron*

By GILBERT S. SCHALLER

The advent of fusion welding offered to industry an entirely new method of joining metals. In common with parallel developments, fusion welding was first applied to problems that were the most urgent and the ones that appeared to fit the new method best. The circumstances of such procedure were both natural and expedient.

Welding through the ages has come to mean the joining of pieces into an entity through the use of what is referred to as fire welding. This method is utterly different in all its essentials from the fusion process. However, the two have the same objective of one whole or one part, at the completion of the welding operation. The conception of a weld was associated with broken parts that had formerly represented a mechanical member or the like. Since the available materials of engineering were quite limited, those which lent themselves readily to the prevailing methods of manufacturing were those most generally used.

Development and Limitations of Cast Iron

It was because of this state of affairs that cast iron rose to a dominating position in the manufacture of machinery parts as well as one of importance in construction and in the more domestic aspects of civilisation. The first broad use of cast iron was in the making of stove plate and similar equipment. The demands placed upon cast iron were both many and varied. The material responded in a manner that reflects great credit upon itself and upon those who pioneered its use. The achievements of these early artisans were such that they must elicit profound admiration, and wonderment at their ingenious skill and ability.

However, cast iron in early industrial development, as now, had its limitations—the material was used where it could not perform as expected. This statement of fact should not, and cannot, condemn cast iron as an outmoded engineering material. There is nothing to be gained by reviewing the failures and breakages that have occurred to other material and production processes where they have been inadequately evaluated or incorrectly used. In the latter circumstance, proper steps have been taken to correct any deficiencies for solutions of lasting and satisfying values. Cast iron is also the beneficiary of scientific study so that it, too, can continue to be a more useful and versatile material for present and indicated future applications.

The one characteristic that must receive emphasis here, however, is that cast iron will never, in any major way, compete with steel or other metals and alloys so far as processes of fabrication are concerned. Cast iron derives its name from the fact that it always occurs in cast form—that is to say, as a casting. There may be rare instances where cast iron is a part of a composite whole that has been fabricated by welding. It is also true that some future development may see cast-iron parts welded to a greater extent than current practice dictates; yet the idea of welding individual pieces of cast iron to form an entity does not now appear as a feasible procedure from the standpoint of costs. In other words, cast iron can be produced more economically in the form of the completed, one-piece casting than it can through any process of building component parts into the finished whole.

From the foregoing, it is recognisable that the large field and the one for major consideration in the welding of cast iron is in the direction of repair and, to a lesser degree, maintenance of existing machinery and equipment. Here, then, is presented a problem to the welder that differs entirely from that encountered in fabrication and erection, the fields in which metallic arc welding has gained its widest application and has deservedly won its greatest acceptance. The problem is that of reclamation and repair on the one hand, as opposed to the building and erection of new work on the other. This situation cannot be too strongly emphasised because the problems—different as they are—call for dissimilar solutions.

Reclamation of Castings

A broken cast-iron part at best represents frustration in a degree commensurate with existing circumstances. It means that the piece as originally used was inadequate for the purpose intended. The cause of the failure may come from a number of sources. The comparative ease with which cast-iron parts can be made has often been the determining factor in its use. Such choice of the easiest method has frequently resulted in breakages and shutdowns that were costly and inconvenient. In such instances cast iron has been condemned without a full review of the facts of the situation. It is often true that more considerate judgment would have avoided the use of cast iron in applications to which it was not specifically adapted. All of this is mentioned because cast iron, as a material, does perform an essential service.

When the broken casting appears for welding, the job is, among other things, of an emergency nature—a situation which complicates an already difficult problem. The cause of the break may be improper design of the casting, which indicates that the welder will be expected to return a finished job stronger than its original or suffer the humiliation of having the weld break in service to the detriment of his reputation, although his efforts constituted a workmanlike endeavour and one based upon both skill and experience. It is an impossibility to make the part sufficiently strong by any welding process if it was designed improperly originally.

The introduction of fusion welding offered to the industry a method for salvaging cast-iron breakage that had, with the exception of "burning on" whereby a new section is actually cast on to the broken part, been confined to patching and riveting as a means of repair. The use of torch welding in this field proceeded as rapidly as converts to this new method were obtained. It is not within the scope of this Paper to portray the splendid record of the welding torch in the field of cast-iron repair, where it remains a major adjunct to industry; it is, however, intended to discuss the contributions made by metallic arc welding in the field of cast iron. The progress of metallic arc welding of grey cast iron has been somewhat erratic, due, in some measure, to the reluctance of the industry to accept cast iron as such, or the fact that it can be welded as cast iron.

German Sabotage Frustrated

The most important early successful attempt at welding cast iron electrically came about as an emergency repair. To be sure, some of the eastern railway systems did some successful welding on locomotive cylinders prior to 1917, and it was the experience gained there that led to the revolutionary idea of making major repairs on marine work. The achievement of the United States Navy in envisioning the possibilities of the use of the electric arc in repairing the sabotage committed on the interned German ships at that time was so brilliantly conceived, and so perfectly executed, that it stands as one of the memorable accomplishments in the history of welding.

In a private communication Capt. E. P. Jessup, U.S.N. (retired), recently wrote: "This work was divided between the various ship repair yards and the Navy Yard, and was carried on under handicaps of various descriptions. With all this uncertainty, however, the first two large ships, the 'Frederich der Grosse,' now the 'Huron,' and the 'Princess Irene,' were ready for sea on August 20, in spite of the fact that the engines on these vessels were among the worst damaged of them all, the 'Irene' having the whole side of the first intermediate valve chest broken out on each engine, the side of the high-pressure cylinder on each engine was destroyed, and other smaller breaks, which, under ordinary methods, would have necessitated the removal of four cylinders, which procedure had been recommended by the surveying engineers. . . . These two vessels were the first in which straight electric welding was used, that is, where patches were not bolted to the cylinder walls. . . ." These accomplishments were made with machines and electrodes far below the standards now available.

Machinability of Welds no Criterion

As the idea of electric welding of cast iron has grown many types of electrodes have been introduced. Among these are some that introduce weld metal that is not cast iron in any sense. Technically, the term "cast iron" is a broad generality embracing a wide collection of ferrous alloys which are characterised by relatively high carbon and silicon contents. For the purpose of welding, it seems well to confine this discussion to grey cast iron because machinery parts subjected to stress and, consequently, breakage are, with the notable exception of malleable cast iron, made of grey cast iron.

Recent developments in the metallurgy of cast iron point the way to further improvement in physical properties through the addition of alloying elements. These researches have resulted in new applications for cast parts and may present further problems for the welder. Essentially, grey cast iron is an alloy of iron, carbon and silicon in which a majority of the carbon is present in the graphitic form. The amount, shape and distribution of the graphitic carbon determines the physical properties of the casting or, in this case, the weld metal.

Discussions of the welding of cast iron usually contain some reference to machinability. Frequently the deposited metal must be machined following the welding operation. Machinability has, accordingly, become somewhat of a "tell tale" or an accepted method of judging the success of the final weld. In the absence of a universally accepted method of measuring machinability, passing judgment on the soundness of a weld from the standpoint of machinability alone is open to broad interpretations and somewhat questionable.

Machinability is interrelated with graphite and iron carbide or combined carbon. In the molten state all carbon is present in the combined state as cementite (Fe_3C). Whether or not the carbon remains in solution or precipitates as graphite depends to a large extent on the rate of cooling. If this be slow and an appreciable amount of silicon be present, cementite disintegrates into its component parts of iron and carbon, which latter is the graphitic form. This disintegration may occur either completely or partially, depending upon the

* Paper (slightly abridged) presented at the annual meeting of the American Welding Society. The author is Professor of Mechanical Engineering, University of Washington, Seattle.

conditions under which the reaction takes place as well as the composition of the material.

This behaviour of cast iron is of paramount interest to the welder because the results he obtains from whatever welding process he uses are governed by the laws appertaining to the solidification and subsequent cooling of the weld metal coupled with the modification of the parent metal that has been subjected to a temperature gradient during the welding operation. He must have a full appreciation of the effects that temperature exerts on the weld, yet, in addition, he must not overlook the possible chemical reactions that occur because of the welding process. Leading considerations are the oxidation of the elements of both the weld and parent metal as well as the pick-up of these or other elements from the weld rod, its coating or, in the case of the torch, the flame when of abnormal character.

Grey cast iron as generally employed is a material of low ductility. A finished weld may crack because the material has no other possibility of caring for changed volume caused by the welding process. Such conditions are most frequently overcome by resorting to preheating and, in some cases, post-heating. The possibility of the welder applying the heat during the welding operation in such a manner as to counter contraction difficulties is present. However, important as expansion and contraction are, the further fact that cooling rate exerts its influence on the metallurgical characteristics of the weld and its adjacent parent metal indicates that thought must also be given to this phase of the welding problem.

In this connection a distinct difference arises as between torch and metallic arc welding. In the former, the heat from the welding operation is widely disseminated through the base metal, while in the arc process a much more localised heat zone is usual. These facts impose conditions that offer the user of either process a wide choice.

Metallic Arc Process Studied

A series of studies has been conducted in the Mechanical Engineering Shops at the University of Washington over the past several years in the field of welding grey cast iron. In all of this work, the problem of welding grey cast iron with the metallic arc has been studied. By way of brief review, early work was directed toward spraying the surfaces to be welded with some known graphitiser, in which connection copper developed distinct possibilities. Later studies concerned themselves with mild-steel electrodes of varying cross-sections covered with dipped coatings. The results showed that changes from the orthodox circular cross-section to one in which more surface area is possible for a given cross-sectional volume offered greater possibilities to the introduction of the elements contained in the electrode coating.

The studies presented here concern themselves entirely with the effect of various substances in cast-iron electrode coatings on the weld deposit. Throughout the investigations, no attempt was made to use any particular materials for the reason that in practice welds must be made upon castings as they appear.

The weld specimens for these studies were cast in the foundry division of the Mechanical Engineering Shops. These castings, which are approximately 1½ in. wide by 3 in. long and ½ in. in thickness, are used as welding specimens by all students in the welding classes. The specimens are cast with bevelled edges in order that no grinding time is necessary. The analysis, which varies somewhat from one heat to the next, is what is known to the trade as machinery cast iron, characterised by a rather high silicon with resultingly large graphitic carbon content. Other castings poured at the same time are processed in the machine-shop division and then assembled into small air compressors and other like equipment. The weld specimens used throughout these investigations are representative of the majority of machinery castings encountered in the industrial field.

The idea of producing home-made welding rods for these investigations was abandoned for the reasons previously stated. All welding rods were purchased from local sources of supply with the exception of a donation of some ¼-in. dia. rods from the manufacturer of this material. With the exception of tests Nos. 11 to 37, where molybdenum-nickel rods were used, all others were made with cast-iron welding rods obtainable from usual sources of supply. Most of the rods were ⅛ in. in diameter and 16 in. long, with the exception already noted.

Preparation of the Coatings

The materials used in making up the shielding mixtures were all obtained from local sources. The graphite was of a high degree of purity and not of the plumbago type. Commercial grades of sodium silicate were used throughout the tests. Cellulose additions were finely ground Douglas Fir sawdust that is abundantly available in this territory. Lignin, a wood pulp by-product obtained locally, was tried as a carbonaceous binder. Its use will be mentioned under test results. The metallic elements introduced in the various coatings are of standard type and can be secured from foundry supply sources.

The various substances that went to make up a given test coating were accurately weighed and measured. The solids were carefully pulverised to ensure smoothness and homogeneity in the mixture. They were then blended and mixed before the addition of the binder was made. Sodium silicate was used most generally for the latter purpose, although lignin, previously mentioned, was introduced either as a substitute or as an additional binder. However, it would be premature to comment definitely upon the desirability of lignin as a binder.

The only means available for placing the coating on the rod was the dipping process. Each electrode used in all of these tests was prepared in this manner, a fact worth noting, since the uniformity accompanying the extruded coatings, so far as thickness and uniformity are concerned, was not a factor. It may be that some of the results that are difficult to interpret were affected by non-uniform coating applications. Frequently it was necessary to add water to the prepared shielding mixture in order to obtain a consistency of proper degree for dipping. The dilution added another factor that required attention in that the coatings needed to be dried before the electrodes were ready for use.

All mixtures were prepared in samples of about 100 ml. These were poured into a graduate cylinder in order to facilitate the actual dipping operation. The graduate was inclined and rotated slowly while the rod to be coated was inserted therein. In this manner as nearly uniform coating as possible under the circumstances was obtained. Both ends of the electrode were coated in like manner so that an exposed area about 1 in. in length remained at the centre for the grip of the electrode holder. This plan allowed for the use of short electrodes, giving much closer control of the arc during the welding operation. Since all of the welding was of the manual type, every opportunity for controlled operation was sought to the end that final results would be obtained under parallel conditions.

The electrodes were set aside on a fixture whereby they were suspended in the centre in order that the coatings could dry without harm or distortion to any of the coating material. In a few instances, the electrodes were oven-dried in order to hasten hardening. This required close temperature control in order to avert puffing and flaking of the coating.

(To be continued.)

Permanent Moulds and their Application to the Production of Non-Ferrous Castings

(Continued from page 155.)

In addition to the use of metal and refractory materials for permanent-mould work, mention might be briefly made of the Holley process[1] which is a combination of the two using a cast-iron mould faced with refractory (china clay bonded with sodium silicate). This process has been successfully applied to cast iron, and there appears to be no logical reason why it should not give results with copper-base non-ferrous alloys providing due consideration be given to the fundamental factors entailed in the founding of different metals.

Type of Castings Suitable for Production in Permanent Moulds

Following consideration of the factors which affect both mould and metal, the only other point outstanding is the question of the type of casting most suitable for production in permanent moulds. This will be principally determined by design and also, as previously pointed out, by the properties of the alloy employed.

So far as design is concerned it is obvious that simple symmetrical shapes are particularly adaptable to manufacture in long-life moulds, and it is surprising how many such castings are available. Valve bodies, taps, cocks, plugs, valve doors and valve wedges, valve lids, spindle nuts, handwheels, bearing shells, valve guides, small propellers, slip-rings, bushes, etc., are just a few examples which readily come to mind. All of these could be made from permanent moulds, but very few serious attempts have as yet been made to do so. Furthermore the advantages to be gained outweigh any practical difficulties likely to arise. The most troublesome factor is undoubtedly that of contraction, particularly in the case of bronzes and gunmetal; if unrelieved, it leads to actual cracking of the castings before they can be extracted from the mould. Much can, however, be done to minimise trouble in this direction by intelligent design of both casting and mould and, where necessary, the use of collapsible inserts made from oil sand or soft dry sand, as shown in Fig. 2. Particular attention should be given to the possible effect of runners and risers restricting contraction, and if there is any chance of this happening collapsible insert bushes should be again employed. Apart from relieving contraction this latter adaptation also materially assists in lifting and increasing the life of tool parts if it has been found necessary to pass runners or risers through them. Very often contraction troubles can be reduced by placing runners at a different point. Alternatively it may be found expedient to overcome contraction effects by the use of a different alloy for casting purposes. For example, it will be extremely difficult to produce a gunmetal spoked handwheel of any size from a permanent mould without the presence of contraction cracks, and here the use of collapsible inserts cannot obviously be applied. However, by the use of aluminium bronze, with its lower liquid contraction, the job becomes feasible. If a still greater margin of safety be desired, the hot strength of aluminium bronze can be appreciably increased by the addition of 3 to 4 per cent. nickel. The substitution of tin by nickel in the bronzes and gunmetals is also useful in preventing cracking for similar reasons.

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The Significance of Hydrogen in the Metallurgy of Malleable Cast Iron

By H. A. SCHWARTZ, G. M. GUILER and M. K. BARNETT

(*Continued from page* 146.)

Effect of Hydrogen upon Graphitising Rate

A really scientific approach to the relation between hydrogen content and graphitising rate would involve the preparation of two lots of metal precisely alike and differing only in hydrogen content. Each would then have to be graphitised in atmospheres of equal total pressure so adjusted as to partial pressure of hydrogen as to maintain the concentration of that element constant even with changing temperature. Graphitisation might then be followed by the usual processes, although it would probably not be feasible to treat several specimens together and remove one at a time at predetermined time intervals. The authors still hope, in the interest of an elegant demonstration, to carry on some such procedure, but, for the purpose of the present Paper, content themselves with two much cruder, but perhaps more practical, problems: the effect of initially present hydrogen, perhaps complicated by the presence of oxygen, and the effect of hydrogen-rich annealing furnace atmospheres.

Specimens from 15 heats of very similar composition as to carbon and silicon and of similar origin, which for some reason differed in hydrogen content in the as-cast condition, were heated for 4 hrs. under precisely similar conditions, buried in cast-iron borings, at 900 deg. C., and the resulting graphite determined. It is known that, in principle, graphitising rate is measured by the amount of graphite so formed,[6] although several determinations on each specimen would make for greater experimental accuracy. The results are set out in Table IX.

TABLE IX.—*Relation of Hydrogen Content and Graphitising Rate.*

Weight per cent. hydrogen.	Per cent. graphite formed in 4 hrs. at 900 deg. C.	Weight per cent. hydrogen.	Per cent. graphite formed in 4 hrs. at 900 deg. C.
0.00020	0.69	0.00060	0.515
0.00025	0.54	0.00064	0.028
0.00030	0.42	0.00080	0.23
0.00030	0.40	0.00080	0.185
0.00046	0.38	0.00090	0.080
0.00050	0.085	0.00100	0.15
0.00052	0.018	0.00110	0.08
0.00058	0.037		

It is not perhaps surprising that, with only commercial control on the uniformity of the metal in other respects than hydrogen, there should be a considerable scatter of results, but a definite strong trend downward in graphitising rate with increasing hydrogen is indicated. Hydrogen from 0.00020 to 0.00046 per cent. inclusive averages 0.49 per cent. graphite formed in 4 hrs. Hydrogen, 0.00050 to 0.00060 per cent. inclusive, is very erratic, but averages 0.21 per cent. graphite, and hydrogen from 0.00064 to 0.00110 per cent. averages a little under 0.12 per cent. graphite. A decrease in graphitising rate with increasing hydrogen is evident.

The effect of gaseous environment on graphitising rate has long been a matter of general interest, and random data were accumulated which may now, in part, be correlated with the effect of hydrogen upon the reaction velocity. The matter is best disposed of by citing individual observations. A certain iron held *in vacuo* for 4 hrs. at 900 deg. C. formed 0.155 per cent. graphite, but in a stream of hydrogen (stored over water) it formed only 0.075 per cent. graphite in the same time. Another sample produced, under similar circumstances, 0.31 per cent. graphite *in vacuo*, and only 0.105 per cent. acetylene, which presumably is completely dissociated at 900 deg. C. A third sample producing 0.77 per cent. graphite in 4 hrs. at 900 deg. C. in quiescent air, produced only 0.25 per cent. graphite in anhydrous NH_3, which again was presumably completely dissociated. It appears quite evident that atmospheres rich in hydrogen, and therefore presumably capable of keeping a relatively high concentration of that element in the metal, seem to have always retarded annealing. In all three experiments the hydrogen content of the metal may have been continuously variable throughout the heat-treatment, since attention was then concentrated on the environment without means of correlating the observations with the composition of the specimen.

Though realising that the technique was not adapted to securing quantitative control of hydrogen concentration, an experiment was undertaken to determine the difference in graphitising rate for a given iron with a very high and a very low hydrogen content.

A given white cast iron was approximately saturated with hydrogen by being made the cathode (0.05 amp. per sq. in.) in the electrolysis of a 10 per cent. NaOH solution for 48 hrs. This is 117,500 coulombs per sq. cm., corresponding to a transfer of 12 grm. atoms of a univalent substance, *i.e.*, 12 grms. per sq. cm. of hydrogen (atomic weight = 1). The specimen was a rod about 1 cm. square and hence having an area of about 4 sq. c.c. The amount of hydrogen delivered was therefore about 48 grms. per c.c. of metal, or about 6 grms. of hydrogen per grm. of iron. Most of this, of course, escaped into the air as H_2.

Another portion of the same iron was heated for 620 hrs. at 420 deg. C. in a stream of dry ("pure" tank) nitrogen to remove as much hydrogen as possible. Any fear that material graphitisation would take place proved unwarranted, for the metal at the end of the treatment contained but 0.03 per cent. graphite.

A portion of the hydrogen-impregnated metal was heated in hydrogen at 1 atmosphere for 5½ hrs., and portions of the initial metal and that which had been treated to reduce the hydrogen so far as convenient for the same time in nitrogen at atmospheric pressure. The graphite at the end of the treatment was then determined with the results shown in Table X.

The figure 1.68 per cent. graphite in the last column of Table X represents practically the attainment of equilibrium for the metal of which the total carbon was about 2.55 per cent. No significant decarburisation was encountered in any specimen. The correction of the value 1.68 per cent. for the 0.03 per cent. graphite formed in the preliminary heat-treatment is only of academic interest and was omitted. The decreased graphitising rate accompanying increased hydrogen concentration in a given metal is plainly indicated. Some increase in nodule number as a result of the preliminary treatment in nitrogen was noted.

TABLE X.—*Graphite after 5½ Hours at 900 deg. C. in Relation to Hydrogen Content.*

Metal condition ..	Hydrogen impregnated	Original	Hydrogen diminished
Atmosphere ..	Hydrogen	Nitrogen	Nitrogen
Per cent. graphite	0.05	0.32	1.68
Weight per cent. H initial	0.00152	0.00040	0.00009
Weight per cent. H final	0.00056	Probably decreased	Probably unaltered

Effect of Hydrogen on Nodule Number

When an element affects graphitising rate it is always important to determine whether this is accomplished by a change in nodule number. The number of graphite nodules (visible at 100 magnification) per sq. mm. of actual specimen surface was counted on each of nine specimens of known hydrogen content and relative graphitising rate. This number was converted into a number per cubic millimetre by methods described elsewhere.[7] The results are given in Table XI.

TABLE XI.—*Nodule Number of Materials Differing in Hydrogen Content and Graphitising Rate.*

Weight per cent. H_2.	Nodules per cub. mm.	Per cent. graphite in 4 hrs. at 900 deg. C.	Per cent. graphite in 4 hrs. at 900 deg. C. per nodule.
0.00020	2,350	0.69	0.00029
0.00025	2,250	0.54	0.00024
0.00030	2,800	0.42	0.00015
0.00030	2,500	0.40	0.00016
0.00052	1,750	0.18	0.00010
0.00080	2,400	0.23	0.000095
0.00090	2,600	0.08	0.000031
0.00100	2,300	0.15	0.000065
0.00110	1,100	0.08	0.000072

The nodule number bears no close relationship to hydrogen content, but the rate of growth per nodule does diminish rapidly and rather consistently with increasing hydrogen content. A mechanism in which hydrogen retards the migratory rate of carbon (or, less probably, the rate of dissociation of cementite) seems indicated.

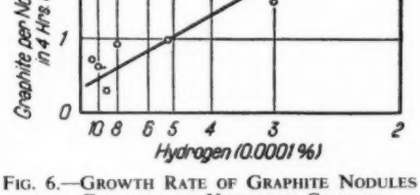

FIG. 6.—GROWTH RATE OF GRAPHITE NODULES AS A FUNCTION OF HYDROGEN CONTENT.

In Fig. 6 the reciprocal of the hydrogen content is plotted against the graphite formed per nodule in a given time, and an approximately linear relation is seen. An expectation that the logarithm of the graphite per nodule might be a linear function of hydrogen content was not confirmed.

Effect of Hydrogen on Mechanical Properties of Malleable Cast Iron

Even though it has been shown that annealed malleable cast iron contains a small and more or less constant amount of hydrogen, there seems to be a fairly definite relation between the hydrogen content of white cast iron and the properties of the resulting malleable. Certain data on air-furnace duplexed malleable compiled from plant records (except as to hydrogen content) are given in Table XII.

Some depreciation of quality might be ascribed to the increase in total carbon; the difference between 2.47 and 2.65 per cent. might represent a decrease of about 1,500 lbs. per sq. in. in tensile strength and 2 per cent. in elongation. Primary graphite is known not to have been present in these test specimens. It is evident that hydrogen very definitely impairs the properties of the resulting malleable even though the effect is to some extent erratic. The mechanism of this effect is interesting and deserves further study.

Table XII.—*Tensile Properties of Malleable Cast Iron in Relation to Hydrogen Content.*

Weight per cent. hydrogen.	Approximate per cent. carbon.	Tensile strength. Tons per sq. in.	Elongation. Per cent. in 2 in.
0.00020	2.47	23.55	18.0
0.00025	2.47	23.90	20.0
0.00030	2.47	23.85	17.0
0.00030	2.65	19.75	6.5
0.00046	2.59	23.30	16.0
0.00050	2.59	23.20	16.5
0.00052	2.59	23.60	14.0
0.00058	2.61	19.95	9.5
0.00060	2.61	18.55	7.5
0.00064	2.61	20.15	7.0
0.00080	2.61	20.55	6.5
0.00080	2.65	19.00	9.0
0.00090	2.65	20.30	11.0
0.00100	2.65	20.25	11.0
0.00110	2.65	20.20	13.5

Conclusions

The investigation here reported may be regarded as extensive rather than intensive. Recognising that none of the investigations has been followed to completion, the authors still hope they have substituted quantitative data for conjecture as a basis for at least qualitative conclusion in a field where speculation reigned supreme.

The following applies to hydrogen as determined by direct combustion and more specifically to metal melted by the cupola/coal-fired air-furnace duplex process. It applies also only to white cast irons of such composition as are commonly encountered in malleable practice since these investigations have not been extended beyond that range.

(1) White cast iron (in a partially graphitised state) will dissolve approximately twice as much hydrogen from a given atmosphere as will pure iron at the same temperature according to Sievert's data.

(2) On a very meagre experimental basis there is no evidence of considerable hydrogen adsorption by graphite.

(3) White cast iron made under commercial circumstances may contain from about 0.0002 to 0.0010 per cent. or more hydrogen by weight.

(4) This hydrogen originates from rust in the charge and from moisture in the air and doubtless from other sources, as fuel, also.

(5) Oxidising reactions during melting reduce the hydrogen content, but in general, the oxygen content of metal high in hydrogen is likely to be high and *vice versa*, though not in any quantitative relationship.

(6) The introduction of a small amount of almost any solid metallic addition into liquid white cast iron reduces the hydrogen content.

(7) On commereial annealing the hydrogen approaches a low constant value somewhat above 0.0001 per cent. regardless of initial content.

(8) At room temperature white cast iron will absorb up to about 0.00150 weight per cent. of hydrogen when used as the cathode in the electrolysis of water.

(9) At temperatures around 400 deg. C. or over white cast iron loses its hydrogen content to a hydrogen-free atmosphere slowly but rather completely.*

(10) Hydrogen from any source very greatly retards the graphitising reaction.

(11) Hydrogen does not seem to affect the "nodule number" of the resulting malleable cast iron, but does seem to affect the migratory rate of carbon in solid solution at least in gamma iron.

(12) White iron high in hydrogen content as the result of melting practice produces iron of lower mechanical properties than iron lower in that element.

As a general statement, it may be said that hydrogen is, weight for weight, apparently the most potent element normally occurring in white cast iron in its influence on the properties. It is even possible that this statement is true atom for atom. Much work remains to be done to elucidate completely the subjects discussed in this Paper and a great expansion of the field of investigation is also desirable. For example, the twelfth conclusion above is at present too far simplified. Additional work is already in progress to determine the mechanism by which an element can affect the mechanical properties of a metal after that element has been removed and to develop methods for the control of that mechanism.

* More recent observations extend the temperature range at which hydrogen is readily removable to much lower temperatures.

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Titanium in Aluminium Castings

INFLUENCE ON PROPERTIES

Data recently issued by the Titanium Alloy Manufacturing Company of New York City deal with the effect of titanium in amounts of 0.1 and 0.2 per cent. added to aluminium for casting. The effect of titanium was segregated from other influences in this work by using a master alloy known as "TAM Webbite" as the source of the element, this alloy being composed of aluminium and 6 to 7 per cent. titanium, with unimportant amounts of impurities. An average analysis is: Titanium, 6.36 per cent.; iron, 0.7; silicon, 0.4; copper, 0.4; manganese, 0.11 per cent. Other factors, such as size of casting, pouring temperature, etc., were kept as closely similar as possible in this work, and all the results were obtained from sand-cast bars, most of them being the average from two to four tests.

One series of tests showed the effect of increasing amounts of titanium on an aluminium alloy containing copper 7.46 per cent., iron 0.3, silicon 0.2, and manganese 0.1 per cent., as given in Table I.

Table I.—*Influence of Titanium on an Alloy containing Cu 7.5, Fe 0.3, Si 0.2, Mn 0.1 per cent., and Balance Al.*

Ti alloy added. Per cent.	Ti content. Per cent.	Y.P. Tons per sq. in.	Tensile. Tons per sq. in.	E. on 2 in. Per cent.	Grains per sq. mm.
None ..	0.015	5.8	7.9	2.1	2.4
1.5 ..	0.105	6.0	8.9	3.0	6.25
2.5 ..	0.144	6.4	9.0	2.5	8.2
3 ..	0.182	6.3	9.6	2.8	156
4.5 ..	0.224	6.0	9.9	2.8	156
6 ..	0.243	6.0	9.7	2.8	156

With over 0.18 per cent. titanium the tensile strength was increased about 23 per cent., which would seem to be a reasonably well-marked improvement, and the grain size was markedly decreased by that amount of titanium. With the larger additions of the master alloy the titanium content of the alloy did not increase proportionately, because without increasing the pouring temperature not more than about 0.25 per cent. titanium can be absorbed.

Tests on another alloy of lower purity, containing copper 6 per cent., silicon 1.2, iron 0.5, manganese 0.3, magnesium 0.7, tin 0.3, and nickel 0.4 per cent., gave the results shown in Table II. This shows about 16 per cent. improvement in strength, with the grain size depending on the titanium content, rather than on the amount added.

Although these tests were carried out carefully in the laboratory they have been checked in normal foundry practice. Instances of such practical results are given in Table III, the alloy used being the common aluminium casting alloy containing about 8 per cent. copper.

In some instances an advantage has been derived from the use of a little titanium tetrachloride, probably as a degasifier, in addition to the TAM Webbite for refining the grain. However, the latter form of titanium is much more widely used because of its convenience and the consistent and definite benefits obtained with it in soundness and strength. It may be mentioned in this connection that a patent on aluminium-copper-titanium alloys, which expired in September, 1937, has disclosed numerous other advantages due to the small titanium content, namely, low crystallisation shrinkage, high resistance to wear, fine grain, and good bearing qualities.

Table II.—*Influence of Titanium on an Alloy containing Cu 6.0, Si 1.2, Fe 0.5, Mn 0.3, Mg 0.7, Sn 0.3, Ni 0.4 per cent., and Balance Al.*

Ti alloy added. Per cent.	Ti content. Per cent.	Y.P. Tons per sq. in.	Tensile. Tons per sq. in.	E. on 2 in. Per cent.	Grains per sq. mm.
None ..	0.02	8.5	8.7	0.8	0.08
2.5 ..	0.095	9.3	10.2	0.9	1.1
2.5 ..	0.138	9.6	9.9	1.0	3.3

Table III.—*Influence of Titanium on 92 Al : 8 Cu Alloy Made under Normal Foundry Conditions.*

Ti alloy added. Per cent.	Ti content. Per cent.	Y.P. Tons per sq. in.	Tensile. Tons per sq. in.	E. on 2 in. Per cent.	Brinell hardness.	Grains per sq. mm.
None	—	6.2	7.0	1.5	47.5	6.25
2.5	—	6.8	10.0	2.2	52.5	44.35
None	0.075	8.0	8.8	2.5	—	—
2.5	0.183	8.3	10.1	2.5	—	—

Powdered Steel

A powdered metal, "Sinterloy," which can be pressed into practically any desired form and then sintered to produce a dense, homogeneous steel, is being marketed in the United States. Suitable for the production of gears, cams, pump rotors, washers, pins, rivets and splined shafts, it is available in three compositions, having 0.15, 0.40 and 0.80 per cent. carbon, each containing carefully determined amounts of chromium; 1.5 to 3 per cent. nickel may be added where toughness is desired. The first two compositions are suitable for case-hardening by the pack-hardening method. The second composition can be heat-treated to a hardness of Rockwell C 40, while the third composition can be hardened to Rockwell C 50. Tensile strengths of from 35 to 53 tons per sq. in. have been obtained.

Formation of Blisters, Pinholes and Black Specks on Vitreous-Enamelled Cast Iron*

By A. L. NORBURY, D.Sc.

Stages in Formation

Fig. 1 shows in a diagrammatic manner the gas bubbles forming and increasing in size and bursting from the enamel surface. It will be noted that between the enamel A and the cast iron C there is a layer of discoloured enamel B which is formed by reaction between the enamel and the iron. When a bubble bursts, this discoloured layer (or dark ground coat, if present) is forced to the surface of the enamel and produces discoloration. If gas is still being evolved when the enamel sets, the burst bubble will not heal up and a pinhole will result. If, however, the gas evolution ceases soon after the bubble bursts the enamel will tend to heal up and a black speck will result. (Black specks may also produce gas from the oxide-carbon reaction.)

In what follows the various different ways in which the above defects can arise are discussed. In practice, it may happen that defects on a single casting are not always due to a *single* cause, but to two or more causes which may operate separately, each producing its own defects, or they may operate together and only produce bad defects when they are operating together.

Bubblies due to Entrapped Gases Escaping

Considering the "entrapped gas" type of gas bubble formation first, since it is the simplest, Fig. 2 shows sections of 3-in. dia. bars, the left-hand group of which were cast in a chilled mould and the right-hand in a sand mould. The top bars in each group are high in total carbon and have open structures, and the bottom bars have lower carbons and closer structures. The iron used was a 5 per cent. silicon iron which was very resistant to oxidation at 760 deg. C. The sections shown in the figure were enamelled *without annealing*, and it will be seen that the rapidly solidified chill-cast sections evolved gas, while the more slowly solidified sand-cast sections did not. When annealed before enamelling none of the sections showed the gas bubble defects on enamelling. This shows that cast iron, if rapidly solidified, may contain entrapped gases which escape on enamelling, if the metal has not been previously annealed. The difference between sand-cast metal and chill-cast metal is only one of degree, and sand-cast sections may contain entrapped gas if they are sufficiently rapidly cooled.

For example, Fig. 3 shows a casting ¼ in. thick by 2 in. by 3½ in., which, again *without previous annealing*, was enamelled on both sides at once, with the exception of a small area in the centre which was not enamelled on the reverse side. It will be seen that entrapped gas has escaped from the casting and caused bubbling all over, except for the small area in the centre which is free from bubbling, owing to the fact that the entrapped gases found it easier to escape from the unenamelled area at the back than to burst through the enamel. This pressure effect is also shown by the violence with which the bubbles burst from the surface of a casting during enamelling, particles of enamel being shot up into the air to a height of several inches.

This question of entrapped gas is not usually of practical importance since most castings are annealed before enamelling and such gases are eliminated. The question of enamelling a casting on only one side or both sides is, however, important, since enamelling on both sides at once is more likely to allow gases from any source to set up sufficient pressure to burst through the enamel. If a sintered porous ground coat is used the pores act as a reservoir in which gases can collect without setting up sufficient pressure to burst through the enamel. Such sintered coats are also less easily reduced by carbon with the formation of gas, since they do not contain easily reduced oxides such as tin oxide.

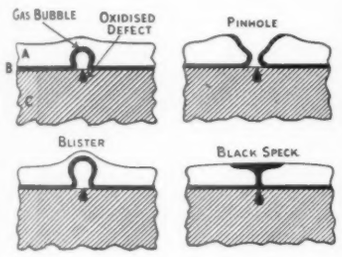

FIG. 1.—STAGES IN FORMATION OF BLISTERS, PINHOLES AND BLACK SPECKS. (A = ENAMEL. B = DISCOLOURED ENAMEL. C = CAST IRON.)

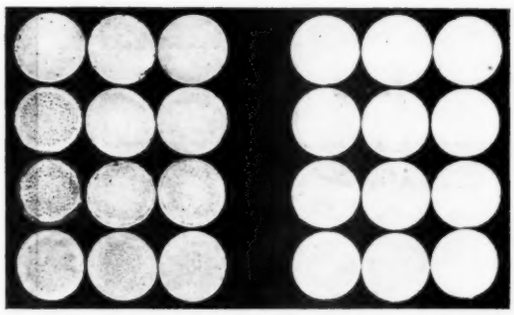

FIG. 2.—SECTIONS OF 3-IN. DIA. SILAL BARS ENAMELLED WITHOUT ANNEALING. CHILL-CAST BARS (LEFT) CONTAINED ENTRAPPED GASES WHICH PRODUCED BUBBLE DEFECTS. SAND-CAST BARS (RIGHT) DID NOT. × 1/12.

FIG. 3.—CASTING ¼ IN. × 2 IN. × 3½ IN. ENAMELLED WITHOUT ANNEALING ON BOTH SIDES AT ONCE, EXCEPT FOR SMALL CENTRE AREA WHICH WAS NOT ENAMELLED ON REVERSE SIDE. ENTRAPPED GASES FROM CENTRAL AREA HAVE ESCAPED THROUGH ENAMEL-FREE SURFACE ON REVERSE SIDE. × 2/3.

may, of course, also be caused by particles of iron or dirt in the enamel.) The diagram only shows the formation of the bubbles, and during the cooling of the enamelled casting it must be imagined that if the thermal contraction of the bubbles is greater than the expansion due to gas still being evolved, the bubble will contract and cause a depression on the enamel surface.

Sources of Gas Bubbles

In Fig. 1 it has been assumed that the gas is formed from a reaction between an oxidised defect and carbon in the metal, with the formation of CO_2 and CO. This is, however, only one type of gas evolution. A second type arises from a reaction between graphite or carbide in the metal and oxide in the enamel, again with the formation of CO and CO_2. Certain enamel constituents such as tin oxide, which is reduced to metallic tin, react rapidly, while others, such as silica, are, of course, not reactive at the enamelling temperature. A third type of gas bubbling arises from the liberation of gases which have been entrapped in the solid metal during solidification. (Rusting after spraying

The following explanation has been given of the function of grip coats: "As regards the use of grip this contains borax, quartz and clay, and is very hard. The use of grip usually eliminates the enamel boil experienced when enamelling normally. It is thought that during the high-temperature firing of the grip, gas evolution takes place before it fuses over, and the resulting impervious layer prevents gas evolution, during subsequent fusion of the enamel proper at a lower temperature." Moreover, the grip coat does not react with carbon in the metal to produce gas, as discussed below.

Bubbles due to Reaction between Enamel and Graphite

Another possible source of gas evolution is that from a reaction between graphite in the metal and certain oxides in the enamel. That graphite reacts vigorously with enamel, giving off gas, is shown by pushing a graphite rod into molten enamel. The reaction is very vigorous, but ceases rapidly owing to the inability of the enamel and the graphite to diffuse into one another. Actually, graphite can be enamelled perfectly, provided there is a vent through which the initially formed gas can escape. This reaction also happens in the case of grey cast iron and in the dry enamelling process is known as the Manson effect, which is that, when the enamel is first dusted on, there is no further gas evolution.

Gas formed from this reaction in the wet enamelling process only forms defects if the graphite size is large, as illustrated by Figs. 4A,

* This Paper was prepared for presentation to a joint meeting of the Institute of British Foundrymen and the Institute of Vitreous Enamellers. It was originally privately presented at the British Cast Iron Research Association's Third Study Course.

B, C, D, which show four different graphite sizes in a cross-section cut from a slab of cast iron 2 in. wide by 6 in. high by 8 in. long, which was cast against a chill on the underside and then cut vertically into ¼ in. thick sections. When one of these sections was enamelled (without previous annealing) the parts near the chill, whose microstructures are shown in Figs. 4A and 4B, did not show any bubbles on enamelling. The parts farther away from the chill, however, with the structures shown in Figs. 4C and 4D, showed increased amount of boiling. Apparently the gas bubbles formed by the small graphite flakes were too small to coalesce, while those formed by the larger flakes were able to do so and produce sufficiently large bubbles to produce visible blisters.

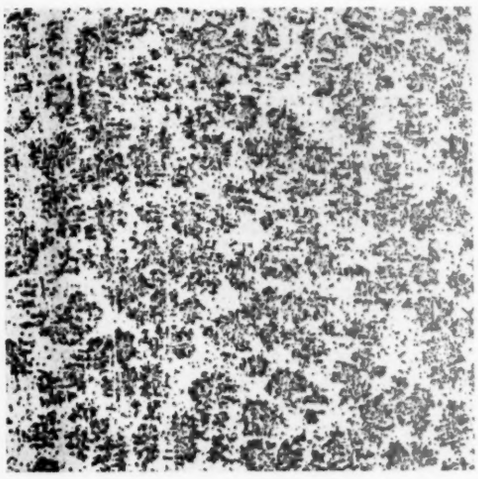

Fig. 4A. × 50.

Fig. 4C. × 50.

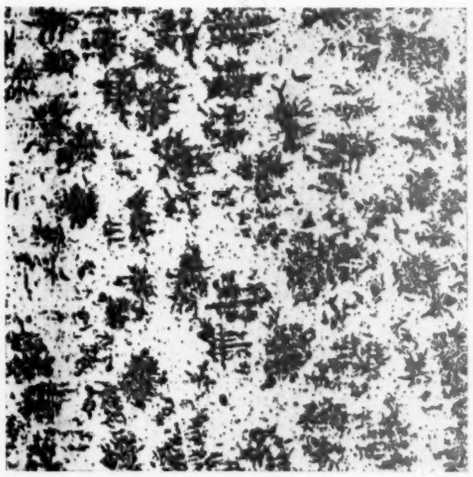

Fig. 4B. × 50.

The fine graphite in Figs. 4A and 4B did not give blisters on enamelling, since the gas bubbles formed by the reaction between the graphite and the enamel were too small to coalesce.

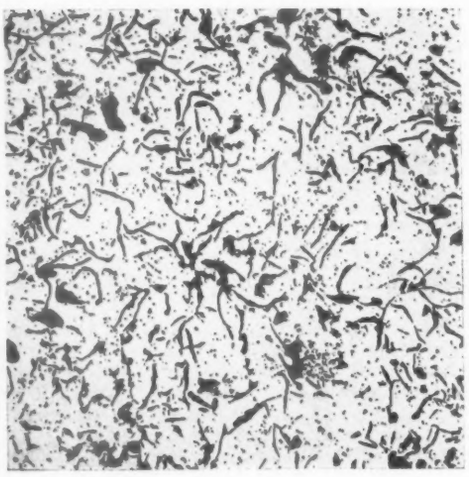

Fig. 4D. × 50.

The coarse graphite structures in Figs. 4C and 4D gave blisters on enamelling.

The boiling on the coarser parts of such sections was considerable if they were shot-blasted before enamelling, but was almost absent if they were emery-papered or honed before enamelling. Other conditions being equal, the boiling was less if the section was annealed before enamelling, presumably owing to graphite being burnt away during annealing. The explanation of the shot-blasting differences appears to be that shot-blasting burnished over the surface graphite and delayed it reacting with the enamel until the latter had fused, after which the attack of the molten enamel on the surface of the metal and the annealing effect of the enamelling temperature each had the effect of uncovering the graphite flakes and allowing them to react with the enamel and produce gas at a later stage in the enamelling operation.

Defects due to coarse graphite tend to be found over a thick boss or along a thick section of the casting, or opposite a runner, that is to say, in the most slowly cooled parts of the casting. Another effect of coarse graphite is that it tends to produce a higher combined carbon in the iron than is produced when the graphite is fine, and combined carbon, as discussed below, is another source of gas formation.

Bubbles due to Reaction between Enamel and Combined Carbon

Combined carbon in cast iron reacts with the enamel in a similar way to graphite, but if not present in too large amounts, may not cause sufficient gas evolution to produce defects. Its presence is, however, undesirable, since it is a potential source of gas evolution. If the combined carbon is considerable in amount, due, for example, to the manganese content being insufficient to neutralise the sulphur present, the resulting high combined carbon will probably produce boiling all over.

In this connection the silicon content is also of great importance, since the lower the silicon content the lower the "critical temperature" of the iron, and if the silicon content is below a certain figure, of about 1.5 per cent., the iron at the enamelling temperature will not be below its critical temperature. This critical temperature is the temperature above which graphite can dissolve and diffuse in the solid iron to form more combined carbon. Consequently, if during enamelling the iron is above its critical temperature, more combined carbon will be formed and can diffuse to replace that which has reacted at the surface of the metal with the enamel, so that instead of the gas evolution ceasing, it will proceed continuously and cause considerable general boiling. If, however, the silicon content is sufficiently high, for example, about 2.5 per cent., the iron will not be above its critical temperature during enamelling, and the reaction between the enamel and the surface combined carbon will cease very early in the enamelling process, owing to lack of diffusion, and the gas evolution will not cause defects as in the previous case, when the reaction went on continuously.

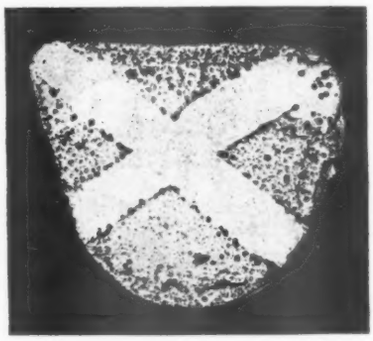

Fig. 5.—Section of Phosphoric Pig-Iron Annealed at 800 deg. C. for 20 min., Scratch-Brushed and Cross-Ground to a Depth of $\frac{1}{16}$ in., then Enamelled. The Reaction between Oxidised Surface and Carbon in Metal has produced Gas Defects. × ½.

Bubbles due to Reaction between Oxidised Metal and Carbon in the Metal

Another type of gas evolution may arise from a reaction between carbon in the metal and oxidised defects below the surface. Oxidised defects right on the surface are removed by efficient shot-blasting. If, however, shot-blasting is not effective in removing this surface oxide—and this is most likely to occur at re-entrants on the surface of the casting—the above oxide-carbon reaction will cause defects. The importance of efficient shot-blasting needs no emphasis.

As an example, Fig. 5 shows a section of phosphoric pig-iron which was annealed in a muffle so that oxidation penetrated a short distance below the surface, down the graphite flakes. It was then cooled, wire-brushed, then the St. Andrew's cross ground on it with an emery wheel to a depth of about $\frac{1}{16}$ in., then sprayed and enamelled in the ordinary way. It will be seen that no bubbling has occurred on the ground, oxide-free cross, whereas vigorous bubbling has occurred elsewhere, due to surface and sub-surface oxide reacting with graphite in the metal.

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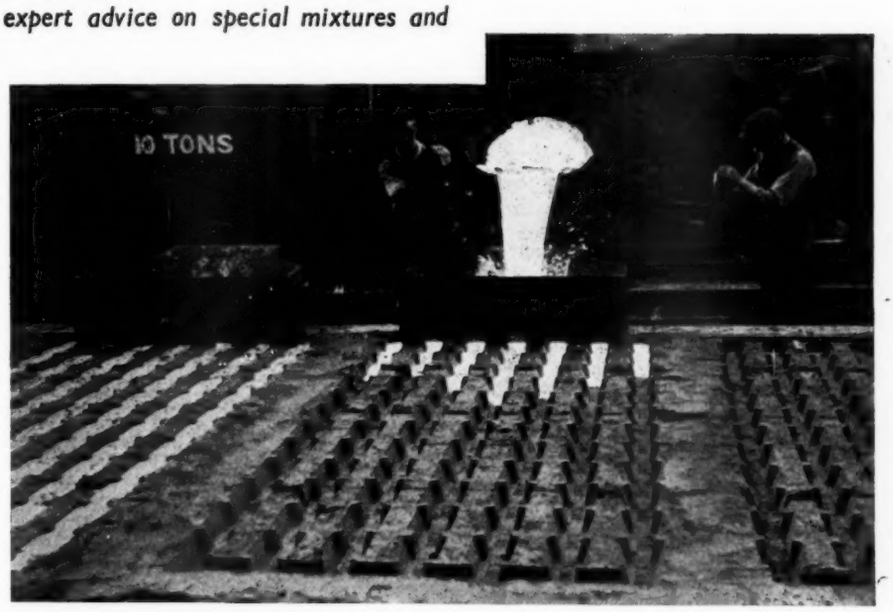

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Formation of Sub-Surface Oxidised Defects

Sub-surface oxide is probably one of the most common sources of defects in actual practice, and may form, as shown in the above case, down coarse graphite flakes. It may also form, as shown in Fig. 6, in what is probably a gas-hole defect near the surface of the casting. The defect was found beneath a crop of pinholes in the enamel, and had become oxidised, probably chiefly at high temperatures, while the casting was cooling in the mould and, to a lesser extent, while it was being annealed and while it was being heated up for enamelling.

Such gas defects in the metal tend to form in the last part of the microstructure to solidify —*i.e.*, round the phosphide—and are more likely to be produced if the metal is poured too cold or if the mould is insufficiently permeable to allow the escape of mould gases. They may be due to sand particles coated with coal dust and clay becoming detached from the mould and giving off gas in the solidifying metal, or they may be due to oxidising slag particles in the metal, such as might arise from the use of a dirty ladle, that is to say, one with an oxidised skull whose oxides react with the metal right up to the moment of pouring.

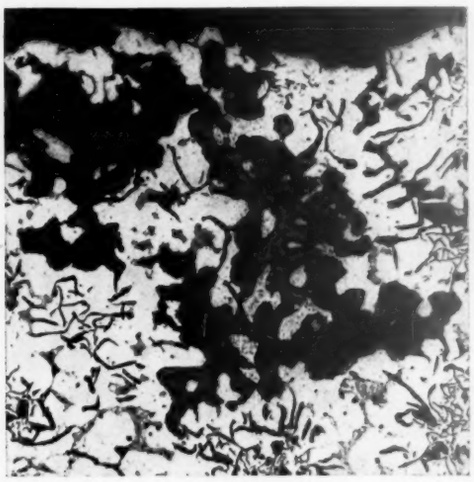


FIG. 6.—CROSS-SECTION OF EDGE OF CASTING BELOW PINHOLES IN ENAMEL, SHOWING OXIDISED POROUS AREA WHICH REACTED WITH CARBON IN METAL TO PRODUCE GAS. × 100.

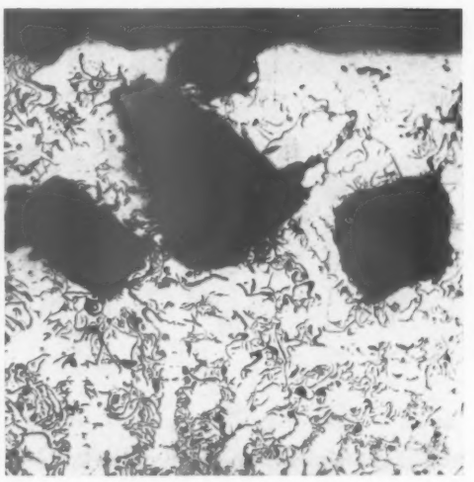


FIG. 7.—CROSS-SECTION OF EDGE OF CASTING SHOWING ENTRAPPED SAND GRAINS. × 100.

Sub-Surface Defects due to Included Sand Grains

That sand grains can become detached from the mould and cause surface and sub-surface defects is shown in Fig. 7, which shows sand grains which have become entangled in the surface of a Silal casting. When blistering of the enamel is due to such defects it will usually be found that if the enamel is removed by shot-blasting, under each enamel defect there will be found a small hole in the casting containing sand grains, as shown in Fig. 7. It will also be found that the holes which communicate freely with the outside of the casting do not give such a bad defect as deeper-seated holes which have only a small aperture connecting them to the outside and which are consequently less effectively cleaned out by shot-blasting. Defects due to entrapped sand grains are often localised in certain parts of the casting—such as the rim of a bath—where the sand is most likely to collect.

Incidentally, it will be noted in Fig. 7 that the graphite flakes are coarsest round the sand grains and at the outside of the casting. Fig. 7 does not illustrate this particularly well, but it has been repeatedly found in castings having supercooled graphite structures that the outside edge, in contact with the sand mould, is coarsened, just as if the sand had an "inoculating" effect, giving coarse graphite where it is least wanted from the enamelling point of view.

Effect of Composition on Enamel

The nature of the enamel will also obviously have a considerable influence on the size of the above gas bubble defects, according to the temperature necessary to fuse it; to whether it will frit at a low temperature and entrap a greater amount of gas than if it fritted at a higher temperature; to its fluidity at the highest temperature and the ease with which it will allow gas to escape and be able to heal up gas holes without forming visible defects. The reactivity of its constituents will also affect the rate at which gas is formed by their reaction with carbon in the metal. The composition of the enamel also, of course, affects its adhesion, liability to crazing, colour, lustre, opacity, corrosion, heat-resistance, etc., but consideration of these properties is outside the present scope.

Relation of Defects in Enamel Coatings to Hydrogen in Steel

By C. A. ZAPFFE and C. E. SIMS

(*Continued from page* 98.)

The progress of hydrogen as it diffuses through steel can be followed by observing the train of defects that it leaves in its wake. The mechanism of "delayed fishscaling" is graphically portrayed by the following simple experiment (Fig. 39). A bar of plain steel, ¾ by ½ by 5 in., was drilled centrally and longitudinally with a ½-in. hole, much as in previous experiments, and the hole was plugged and welded. A glass rod was placed in the hole before sealing to decrease the volume of the cavity. The specimen was prepared by the ordinary procedure, baked at 115 deg. C. for over an hour to drive out all dissolved hydrogen, and fired with blue ground coat. During firing, the hydrogen, which had occluded in the cavity during pickling, re-dissolved and diffused through the two thinner walls, each of which was ¼ in. thick, and caused a long seam of blisters directly overlying the cavity on each of the two flat faces. No blisters appeared elsewhere. Before the piece had cooled, most of the blistered enamel on both faces exploded away in large chips. In the next few hours, the enamel immediately bordering on the blistered seams exploded away in large chips; one day later, enamel still farther away was chipping, and so on. As time passed, the fishscaling progressed to areas ever farther from the cavity, and the chipping occurred less at the metal surface and more in the coating itself, finally appearing as the customary fishscale. The fishscales also became smaller and occurred less frequently, finally appearing as tiny specks, which are apparently the "crystallites" that are often described as a separate defect.

The important thing to note in Fig. 39 is that the hydrogen diffusion directly over, and very close to, the central cavity has been so severe that the metal is completely bare and that at greater distances the fishscales become progressively smaller and fewer. On the narrow faces, ¼ in. and more away from the hole, fishscales did not appear until several weeks after firing, and they were very small. The specimen had been placed in a container immediately after cooling, and at periodic intervals the chips and scales were collected. The chronology of blistering → fishscaling → delayed fishscaling is shown in Fig. 40. Each group of scales represents the enamel exploded from just one of the blistered faces between the intervals of gathering. Note the large bubbles in the early chips, and the gradual disappearance, first, of bubbles, and then black oxide as the diffusing gas slowly moves away from its origin; also note the corresponding decrease in the amount of chipping. At the end of one week, the chipping occurred almost solely within the enamel coating itself, for effusion had become so slow that the gas almost escaped through the enamel before sufficient pressures were obtained. When effusion is slow, the variations in permeability of the various zones in an enamel coating become important factors. Apparently the most impermeable section of a vitreous enamel coating is the outermost glazed layer.

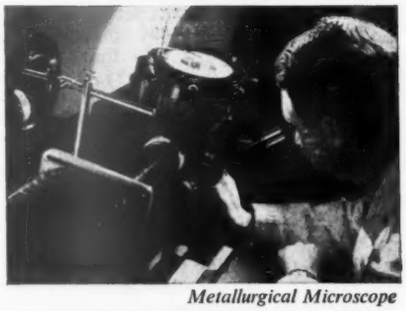
OTHER DEFECTS

Other defects in enamel coatings in addition to those already discussed will be mentioned briefly to point out that the effusion of hydrogen from the steel during enamelling may indirectly influence the formation of other defects.

Copperheads

For example, "copperheads" are plainly due to local concentrations of iron oxide, and yet Cook finds that longer pickling periods are conducive to copperheading and that some irons are more susceptible than others. Several other observations at least imply that hydrogen in some cases is also present during the formation of copperheads; Schaal and Fuller believe that copperheads are related to reboiling, fishscaling and to gas evolution in general. It might also

Casting test bars in sand



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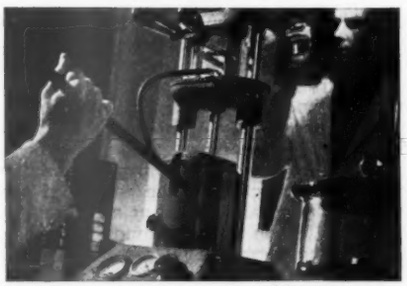
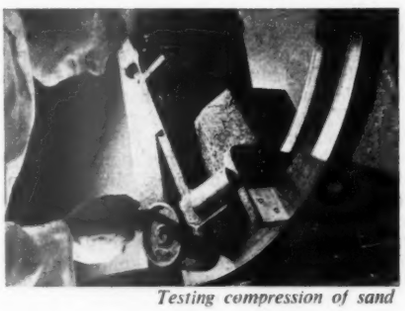


Mounting press



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be pointed out in addition that if the hydrogen evolution is sufficient to lift the enamel off the steel and expose the bare steel to an oxidising atmosphere, copperheading will result. A particularly interesting case of copperheading may be observed in Fig. 37 (right), where a great range of copperhead-type blemishes has resulted directly from the evolution of hydrogen that occurred during the baking period of the enamel slip. It will be recalled that, in this experiment, carbon in the steel had retained so much hydrogen from the pickling operation that evolution of the gas caused fishscaling in the first layer of ground coat and that continued evolution from the loci of these fishscales caused "slipscales" to form in the slip during baking and while coming to temperature during firing. Where the fused enamel did not flow over these bare areas and completely absorb the oxide, copperheads and other blemishes resulted. Well-exposed spots were copper-coloured, and less exposed spots were black, which conforms to the various oxides of iron that would result from variously oxidising conditions.

Gas evolution during the "boil," of course, is similarly effective. The correlation between copperheads and hydrogen in the steel is therefore obvious; and an important point to note is that the increase in hydrogen effusion that occurs at baking or early firing temperatures may lift or explode away small pieces of the enamel slip, exposing the steel surface to oxidation.

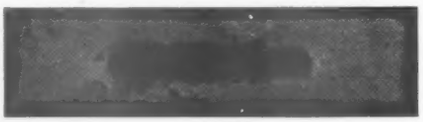

Fig. 39.—Blue Ground Coat on Steel Bar with Central Cavity, showing Train of Defects caused by Hydrogen occluded during Pickling and liberated during Firing.

5 min. 2 hrs. 150 hrs. 2 days.

3 days. 4 days. 5 days. 1 week.

Fig. 40.—Chronology of Blistering and Fishscaling illustrated by Groups of Scales exploded by Hydrogen from One Face of Specimen in Fig. 39 during Time Intervals as Noted.

Black Specks

"Black specks" in most cases are probably closely allied to copperheads and represent smaller areas of lesser oxidation, hence Fe_3O_4. Here again the defect is related uncertainly to pickling, but certainly to blistering and boiling, to the iron, to the furnace gases, and to incorrect drying. Black specks also appear on the specimen in Fig. 37 (right).

Blister-Type Defects

"Pinholes," "pimples" and "glass eyes" are apparently the result of gas evolution during firing.

Fishscale-Type Defects

"Shivering" is another enamel defect. "Pop-offs," "jumpers" and some cases of "chipping" can be identified as defects that may be caused by an effusion of hydrogen underneath the hardened enamel, as are fishscales. "Bursting" of the enamel on cooking utensils may well be due to the same mechanism.

Miscellaneous Defects

"Cracking" has been related to the composition of the metal and to welds and to slag inclusions. "Hairlines" and "crazing" quite likely are results of the shrinkage and mechanical stresses. "Curling," "tearing," "crawling," "lifting," "orange peel" and "ripple" finish, and "knobs" are other defects.

Thus there are plenty of enamelling defects arising from causes other than hydrogen. The complete avoidance of hydrogen, could it be accomplished, would not guarantee perfect enamelling. In seeking for a better understanding of the causes of enamelling defects, one should list all possible causes and instead of entirely omitting hydrogen from this list, as has so often been done, one should not only be careful to include it, but to regard it as a most prominent suspect. Because of its omnipresence and the various phenomena by which it manifests its presence, hydrogen at least should be considered when seeking the cause of practically any enamelling defect. If the authors have seemed to over-emphasise the importance of hydrogen as a source of enamelling defects, it probably seemed necessary in order to compensate for the slight attention it has hitherto received.

Conclusions

From the foregoing work the following conclusions may be derived:—

(1) Hydrogen is inherently present in every steel and iron, but in widely different amounts. The steelmaking process is responsible for this initial hydrogen content, because the solubility of hydrogen in steel is several thousand times greater at steelmaking temperatures than it is at ordinary temperatures. The extreme supersaturation that results during cooling forces the atomically dissolved hydrogen to precipitate in every available discontinuity, however small, where it immediately recombines to form highly insoluble molecular hydrogen; and the nascent condition of the atomically dissolved gas encourages reactions with impurities in the steel. The resulting total retention of hydrogen is so great that surprisingly large quantities are held in steel.

(2) To this inherent quantity of hydrogen is added more hydrogen by the pickling operation in the steel plant to remove scale and in the enamelling procedure for preparing the specimen, by ordinary rusting reactions, by welding, and by reactions during firing with furnace gases and with the moisture chemically held in the enamel slip.

(3) Hydrogen dissolved atomically in the steel may cause enamel defects because diffusion is exceedingly slow at ordinary temperatures and equilibrium may not be reached unless the steel is carefully treated.

(4) Hydrogen occluded in cavities as molecules will be released only when the steel is brought to enamel-firing temperatures, and then the solubility of the gas has so increased that very little need be lost into the atmosphere. The initial release is indicated by the formation of bubbles in the soft enamel, and the resolution is evidenced by the fact that blisters soon collapse and "boiling" subsides. Upon cooling, the hydrogen may again largely seek the discontinuities from which it originated, and the remaining portion may precipitate at the metal-enamel interface to cause the scaling defects already enumerated, providing the permeability of the coating is unfitted to the quantities of gas that precipitate. This type of action accounts for the cyclical nature of boiling phenomena.

(5) Hydrogen retained in inclusions or segregations of impurities may or may not react with the impurity to form compounds that are more or less stable in contact with iron than is molecular hydrogen. If no reaction occurs, the occluded gas will behave as molecular hydrogen in a cavity. If reaction does occur, the hydrogen will be liberated to the steel at temperatures that depend on the product that has been formed.

(6) Hydrogen retained by molecularly dispersed impurities, such as carbon, will also be liberated at certain elevated temperatures. The case of carbon is particularly interesting and is most important. The chemical bond between carbon and hydrogen, particularly between unstable cementitic carbon and atomic hydrogen, is very strong, and large amounts of hydrogen conveniently collapse around carbide particles to form, perhaps, a quasi-methane structure. These iron-hydrocarbon structures decompose during firing to liberate hydrogen, and the resulting boiling action at the enamelled surface has been wrongly identified as a carbon-oxygen reaction. Carbon oxides compose a fraction of the blistering gases, but hydrogen predominates. The decarburisation that is sometimes noted in surface layers may be due to hydrogen activity as well as to a carbon-oxygen reaction; and the observed effect of pearlitic segregations on blistering is abetted by the possible presence of molecular hydrogen occluded in the interdendritic interstices that characterise segregations. The relation of miscrostructure of the steel to enamelling defects is largely coincidental because the solubility of hydrogen varies markedly with the phase changes. In regard to cast iron, hydrogen is associated with white iron, and the decomposition of the white iron liberates hydrogen, which in turn may cause many of the defects in cast-iron enamelling. Steel with considerable carbon content may be successfully enamelled if its hydrogen content is carefully controlled. Pure graphite may be enamelled without significant boiling action, although adherence is poor.

(7) Because the liberation of hydrogen from steel occurs at temperatures that depend quite closely on the condition of the occluded gas, it should also be possible for the enamelling industry to use some steels that contain large amounts of inclusions; that is, as has been shown, if the included matter is predominantly of a certain type, the impurity may react with

(*Concluded on page* 168.)

W

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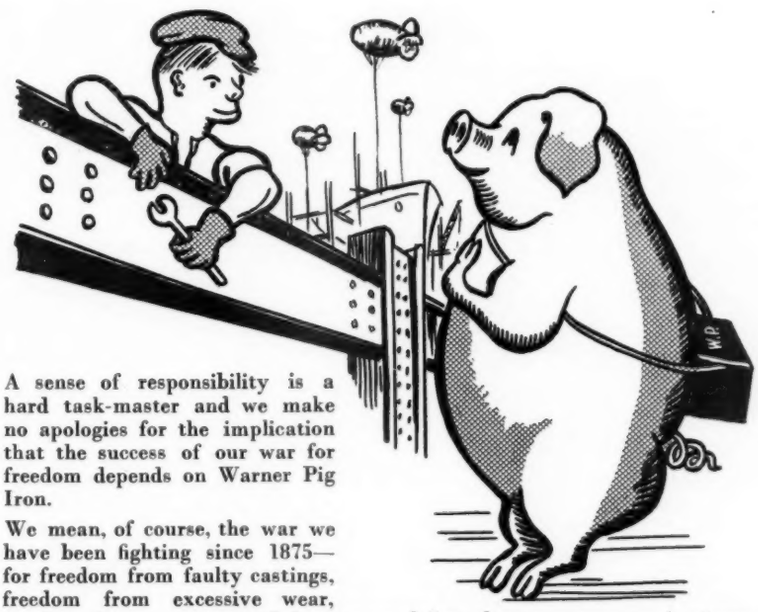

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AT THE ANNUAL LUNCHEON of the Institution of Factory Managers, held in Manchester, the Sir Henry Fildes Silver Medal was presented to Mr. John Edwin Jefferies, of Southport, for a Paper on "Some Improved Methods of Factory Management."

SIR ISAAC PITMAN & SONS, LIMITED, announce that, by an agreement with International Engineering Publishing Company, they are to publish twenty-two engineering handbooks in Spanish. The books are grouped in three series: Civil Engineering, Electrical Engineering and Mechanical Engineering, and the main object of these authoritative publications is to introduce British practice and British Standard Specifications in Latin-America.

THE Minister of Aircraft Production has made the Light Metals and Alloys Fabrication (No. 1) Order, 1941, which came into force on February 25. The Order provides that no person may fabricate light alloys and light metals without a licence, and that no licensed fabricator may dispose of his products except under the directions of the Minister. All inquiries should be addressed to the Ministry of Aircraft Production, Light Alloys and Magnesium control, Southam Road, Banbury. Copies of the Order may be purchased at H.M. Stationery Office.

THE possibility of the "little mester" type of manufacturer playing a bigger part in producing munitions is being canvassed in Sheffield. One suggestion is that the sum total of munitions manufactured in Sheffield could be substantially augmented by the provision of a central building to act as a receiving and distributing centre, from which work could be collected by small contractors, passed out to them for operations in which they could be quickly trained, and returned by them to the central depot, to be again passed out for further manufacturing operations.

DECISIONS regarding the liability to Purchase Tax of stoves, grates and ranges which modify those previously published have just been announced by the Secretaries' Office of Customs and Excise. They are as follow:—*Class* 7. *Domestic Cooking and Heating Appliances.* Chargeable at the rate of 33⅓ per cent.: Adaptable fires and barless fires (including a complete fire basket and fret); ovens for domestic stoves, grates and ranges; boilers, *e.g.*, independent, back, side, ell, boot, etc., for domestic heating purposes. Mantel registers and surrounds (whether of tiles, metal, or other materials) sold as separate parts are not chargeable; but any domestic cooking or heating appliance sold complete with mantel register or slabbed tile surround, etc., is taxable on the wholesale value of the complete article supplied. *Class* 9. *Articles of Hardware and Ironmongery of Kinds used for Domestic or Office Purposes.* Chargeable at the rate of 33⅓ per cent.: The following parts and accessories for domestic stoves, grates and ranges: Ashfronts, ashpans, ash preventers; bottoms, including false bottoms; coal savers; coal savers and trivets combined; drawplates; fire baskets and grate bottoms; firebacks and cheeks of firebrick or metal; frets, grate fronts and trivets; hearth plates of the portable type; hearth stands and plate stands.

Company Meeting

Mather & Platt, Limited

Presiding at the annual meeting of Mather & Platt, Limited, MR. L. E. MATHER (chairman) said that while the profits of the company showed only a small increase, the figures and a careful analysis of them indicated a strong position. As they were a Government-controlled establishment, he could not refer to their manifold activities during the period under review, but they were fortunate in that most of their standard lines of production were required.

Personal

MR. B. GALE, until recently honorary secretary of the East Midlands Branch of the Institute of British Foundrymen, has left Derby to join the staff of a well-known Scottish aeroplane factory.

MR. H. SIMPSON, Vice-President of the American Foundrymen's Association, who has been appointed chairman of a newly-formed membership committee, has presented a trophy, taking the form of a gong, which will be held by the branch showing the greatest growth in membership.

MR. C. R. D. TUCKEY, the well-known Davis Cup player who, with G. P. Hughes, won the "Doubles" at Wimbledon in 1936, has been appointed head of the planning department of British Timken, Limited. Mr. H. K. B. Glassey, who has been with the firm for twenty years, has been appointed assistant sales manager.

Wills

BENNETT, C. V., of Rochester, past-President of the Institute of Gas Engineers £30,391

DAVIES, G. K., of Stourbridge, a director of G. K. Davies & Company, Limited, hollow-ware manufacturers £3,008

WOOD, SIR ARTHUR NICHOLAS LINDSAY, Bt., of Chester-le-Street, mining engineer, chairman of A. Reyrolle & Company, Limited, electrical engineers, of Hebburn, and a director of the Harton Coal Company, Limited, and other colliery concerns £188,399

Obituary

MR. FREDERICK CARLISLE BEDFORD, managing director of Lockwood & Carlisle, Limited, piston manufacturers, Sheffield, has died after a short illness.

MR. JOHN RIDYARD, secretary of the Sheffield Lighter Trades' Employers' Association, which comprises the Cutlery Association, File Association, and various other bodies, died last month.

MR. CHARLES JOSEPH SEAMAN, of Buxton, who has died at the age of 86, was formerly manager and director of Heenan & Froude, Limited, Newton Heath Ironworks, Manchester, and Worcester.

MR. WILLIAM SHIPMAN, who has died at Stockton-on-Tees, had spent 50 years in the service of the South Durham Steel & Iron Company, Limited, and its predecessors. He was for 22 years at the old Moor Works, Stockton, and for 28 years at West Hartlepool, where he became assistant manager.

SIR ALLAN M. SMITH, who died suddenly at Hampstead last week, in his 70th year, was a solicitor, who became chairman of the Shipbuilders' Federation and of the Engineering and Allied Employers' National Federation. During the last war he was appointed by Earl Kitchener to the Armaments Output Committee, and played an important part in speeding up the production of shells. He was knighted in 1918 and represented South Croydon in Parliament from 1919 to 1923. Sir Allan resigned his chairmanship of the Engineering Employers' Federation in 1934.

MR. CHARLES JOHN WALSH, managing director of the United Steel Companies, Limited, and of the Appleby-Frodingham Steel Company, Limited, Scunthorpe, has died at his home at Babworth, Retford. A native of Birmingham, Mr. Walsh studied metallurgy at Birmingham Technical College and gained practical experience with firms in the iron and steel industry before joining John Walsh & Company, iron and steel merchants, Birmingham. In 1909 he went on the board of the New Conveyor Company, Limited, Smethwick, of which he was chairman, and in 1911 relinquished his interest in John Walsh & Company, Birmingham, to become general manager of Ibbotson Bros. & Company, Limited, Globe Steelworks, Sheffield, later becoming managing director of the firm. Ultimately he joined the United Steel Companies, Limited, becoming managing director. He was Master Cutler in 1933.

Reports and Dividends

Lightalloys, Limited—Interim dividend of 12½ per cent.

United Steel Companies, Limited—Interim dividend of 2½ per cent.

R. & W. Hawthorn Leslie & Company, Limited—Interim dividend of 3 per cent.

Leyland Motors, Limited—Interim dividend on the ordinary shares at the rate of 10 per cent. per annum.

J. Brockhouse (Ireland), Limited—Net profit to October 31 last of £2,566, reducing the debit balance carried forward to £1,951.

Bairds & Dalmellington, Limited—Net profit for 1940, £218,539 (previous year, £260,970); final ordinary dividend of 12 per cent., making 16 per cent. Meeting, March 24.

Relation of Defects in Enamel Coatings to Hydrogen in Steel

(*Concluded from page* 166.)

the occluded hydrogen to form a compound that is stable enough at enamel-firing temperatures to prevent liberation of critical quantities of the gas. Given a steel with a certain predominating type of impurity, the problem then is to select an enamel that matures at a temperature that is below the temperature at which the steel releases its hydrogen or at a temperature that is sufficiently above that of hydrogen liberation so that the gas may escape while the coating is porous.

(8) A primary cause of (*a*) "fishscaling," "delayed fishscaling" and "shiners," without important exception, (*b*) a cause of "pop-offs," "jumpers" and many cases of "chipping," and (*c*) perhaps of "bursting" is hydrogen which effuses from the iron or steel at temperatures where the enamel is rigid. "Delayed fishscaling" is the result of a sustained, slow effusion.

(9) A predominating gas reaction in producing the blistering and bubbling phenomena in molten enamel on steel, and very likely also on cast iron, is the evolution of hydrogen from the steel rather than the reaction of carbon and oxygen to which the phenomena are usually ascribed.

(10) "Copperheads" and "black specks" are indirectly related to the hydrogen content of the enamelling stock by virtue of the relation that exists between these two types of defect and blistering and fishscaling.

(11) This Paper is presented to show the effects of hydrogen in causing enamel defects. It is realised that good enamel stock must meet other requirements, such as workability, resistance to warping, etc. The investigation is to be continued, directing the study to the lower carbon compositions commonly used commercially. The present investigation indicates that when the steelmaker and the enameller approach the problems of providing steel and the enamelling of it with due consideration of the relation that hydrogen bears to the enamelling process, the tasks of both should be lightened.

Forthcoming Events

MARCH 15.

Manchester Association of Engineers:—Tea dance, in Manchester, at 2.45 p.m.

Institute of British Foundrymen

MARCH 8.

Scottish Branch:—Annual general meeting, followed by a Paper by Dr. J. W. Donaldson, in Glasgow, at 3 p.m.

West Riding of Yorkshire Branch:—"Non-Ferrous Practice, with Special Reference to Light Alloys," Paper by N. C. Ashton, in Bradford, at 6.30 p.m.

MARCH 11.

Burnley Section:—Annual meeting, followed by short Paper, in Burnley, at 7.30 p.m.

MARCH 18.

East Anglian Section:—Annual general meeting. "Precautions to be Taken in the Production of Sound Malleable Iron Castings," Paper by V. N. Wood, in Ipswich, at 3.30 p.m.

"G.R." FIREBRICKS which enjoy the confidence of leading engineers:

GLENBOIG SPECIAL:
For use in all types of combustion chambers & furnaces operating at high temperatures.

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For suspended arch blocks and all blocks subject to thermal shock and high temperatures.

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Unequalled for general furnace construction, boiler linings, baffles, etc.

GLENBOIG CROWN:
For suspended arch blocks, throat bricks—wherever freedom from spalling is the most important factor.

CASTLECARY:
General Furnace work, boiler linings, etc.

GEM:
All positions where conditions are less severe than those which necessitate the use of first grade Scottish Firebricks.

ADAMANTINE:
Hard vitrified firebricks highly resistant to abrasion—extensively used in cool end of re-heating furnaces.

LLANGENNECH:
For use in secondary positions. Good shape and size.

WHITE CARR:
A general purpose firebrick, especially suitable for ladle linings in steel works.

STOURBRIDGE:
Standard Stourbridge firebrick of excellent shape and size.

HIGH REFRACTORINESS *freedom from spalling*

THESE two important factors are provided for in the range of firebricks supplied by General Refractories. An exacting control of the raw materials available from its many firebrick works throughout the country—the use of the most modern equipment—the rigid application of laboratory tests at each manufacturing stage—these ensure a supply of sound firebricks of uniform quality, shape and size.

The resources of General Refractories enable them to offer a range of refractories suitable for the execution of any contract. The user may, therefore, depend upon receiving carefully considered and unprejudiced recommendations directed solely to ensure maximum life and dependability from his furnace structures.

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BASIC BRICKS: *Spinella, Saxpyre, Supermag, Diazite, Dolomax.*
ACID-PROOF REFRACTORIES: *Obsidianite, Losol.*

INSULATION: *Amberlite* Bricks, Cement and Concrete.
SILICA BRICKS: *Lowood, Meltham, Allen, Quartex.*
CEMENTS: *Sintex, Durax, Pyrolyte.* PLASTICS: *Durax, Rotaline, Plastic K-N., Glendoline, Ground Ganister, Steel Moulders' Compositions.* SILLIMANITE: *Tank Blocks, Bricks and Cements.* SANDS: *Moulding, Brick Facing, Silica, Glass*

Raw Material Markets

The light foundry trade is happily placed in respect to supplies of raw materials. High-phosphorus iron is used in the main by consumers in this branch, and ample tonnages are forthcoming to meet all demands. This iron is produced from home ores, which can, of course, be secured much more readily than the foreign ores required for the manufacture of low-phosphorus iron and hematite. Heavy engineering establishments are calling for substantial tonnages of low-phosphorus and hematite irons and, most of these concerns being engaged on work of national importance, their needs are being satisfied, even though at times it becomes imperative to use material imported from the United States and other sources. Foreign iron is naturally very much more expensive, but the selling price to consumers is the same as that of home iron, the balance being met from the central fund set up to finance consignments brought into the country from overseas by the Control authorities.

Pig-Iron

MIDDLESBROUGH—Owing to the preoccupation of ironmakers in the Cleveland area with the manufacture of iron for steelworks, foundry iron consumers here are buying their supplies from the Midlands, and, despite the longer journeys from the furnaces to the consuming points, this system is operating satisfactorily on the whole, although recently there have been instances of delayed deliveries due to transport hold-ups. Adequate supplies of iron are available from the Midlands, however, and users are securing licences to cover their full requirements. Most works have, in fact, small stocks on hand, which have proved of value when deliveries have been irregular. The hematite position remains very tight, with supplies available only for first-priority users. Even so, home production is insufficient to satisfy all orders for important work, so that use is being made of foreign material. There are prospects of increased outputs being possible later in the year, but for the time being the Control are exercising the utmost care in making allocations. Refined iron is being incorporated in furnace mixtures where possible, while a certain amount of high-phosphorus iron, too, is being utilised in order to relieve the situation.

LANCASHIRE—Heavy engineering works continue to be very actively employed, especially the speciality concerns, orders placed by Government departments being quite equal to the productive capacity of the works. Both common and refined grades of pig-iron are in heavy demand and supplies are forthcoming in reasonable tonnages, although transport difficulties are encountered from time to time. The position of the light-castings trade varies, some works having fuller order-books than others; there has been a big improvement in this trade during the past six months or so, but many factories would welcome additional specifications. Some jobbing foundries have also been rather quiet of late, but there is a moderate call for iron from this section.

MIDLANDS—The call for deliveries of high-phosphorus iron is on a good scale, and all demands can easily be met, producers having considerable stocks on hand. In fact, these stocks have assumed extensive proportions at some points and distributors will be glad of any opportunity to liquidate supplies. The chief users of this type of iron are light-castings makers, who are now making rather heavier demands for iron, business in this industry having improved, especially in connection with builders' requirements. The volume of Government work placed with manufacturers of light castings has not yet been heavy, but it has, nevertheless, helped many works to improve their positions considerably. Owing to the closing of many home and export outlets because of the war, the trade was poorly situated for many months. On the other hand, heavy engineering works have been actively employed—mostly on Government work—for a long time past, and the prospects are that more and more urgent work will be handed out to these concerns in the future. Supplies of low-phosphorus iron and hematite are not entirely satisfactory and, where possible, users are making use of refined and other grades of iron, but priority consumers who can prove the necessity are being supplied with imported iron, and there are no instances of operations having been interrupted due to insufficient iron.

SCOTLAND—The bulk of the demand for pig-iron emanates from the heavy engineers, which are busily employed on work of national importance. Although there are occasional delays in deliveries, their requirements are being met satisfactorily, but not always without the aid of iron secured in overseas markets. Light-castings makers can get all the iron they need from the English Midlands, but consumption is not particularly substantial, many works being in need of additional business. On the whole, however, this trade is able to report improved conditions from those prevailing a few months ago. Steelmaking irons are in heavy request and adequate deliveries are being made.

Coke

Current demands for foundry coke are well satisfied, and quite a considerable amount of forward contracting is being done, the makers' stipulation being that the price paid is that ruling at the time of delivery. Prices of coke for some time past have been subject to official control, the present quotation for Durham best coke, delivered Birmingham and Black Country stations, being 61s. 6d. per ton.

Steel

Steelmakers are receiving adequate supplies of raw materials to cope with their ever-increasing needs, and outputs continue to be at record levels. Despite this gratifying state of affairs, however, it is still necessary for the Control to make considerable purchases of foreign steel, so heavy are the Government's steel requirements. Works are, of course, dealing first with orders bearing special priority labels, and there is a considerable volume of this work on hand. Delays in deliveries of other orders are thus rather lengthy at times. Structural steel is in less demand in all districts, but the call for special steel for the production of shells and munitions generally continues to rise. In fact, it is likely that ordinary commercial grades of steel will tend to be in reduced demand as the pressure for special descriptions becomes more insistent. The ordinary domestic trade in steel is virtually closed, but a certain amount is being released in special circumstances for export.

Scrap

Many consumers of scrap iron and steel are willing to accept more material than is at present coming to hand, the steelworks, particularly, requiring all the scrap they can secure. Unless additional supplies soon come to hand, it may become necessary for the authorities to take steps for the compulsory collection of scrap, where this would result in larger tonnages being brought out. The collection of demolition scrap has been disappointing as yet, and it is felt that considerable quantities of this material could be distributed among consumers. Transport delays are still being met with at times in the delivery of scrap, but these tend to become less troublesome.

Metals

Tin—While the prospect of Japanese interference with tin shipments appears to have subsided, developments in the Far East are likely to continue to have a profound influence on the trend of the tin market in this country. The downward movement in quotations, which followed the spectacular rises a week or so ago, was arrested on Friday, when the cash price jumped 30s., three months closing 65s. higher on the day.

It is expected that the American tin smelter, which is to be operated by the Billiton Maatschappij, will take about a year to build, but before full-scale production is attained, a period of some 18 months or more is likely to elapse. By the time the smelter is ready for operations it is prob very substantial tonnages of Bolivian will have been accumulated, as the contract for the supply of the ore dates back to the beginning of July last. At present, it is understood, ore is being stored at Chilean ports. The total purchases of tin by the American Metals Reserve Company were stated last week to be 56,986 tons, although a considerable proportion of this has not yet been shipped.

C. S. Trench & Company, Inc., of New York, in a recent market report, state that, during 1940, they calculate that visible and invisible stocks of primary tin in the United States underwent an increase of almost 45,000 tons, and that at the end of the year such stocks had risen to about 74,000 tons—a year's consumption based on the present rate. They figure that Government holdings (Metals Reserve, Procurement Division and Navy Department) increased from around 5,000 tons on December 31, 1939, to around 25,000 tons on December 31, 1940, while consumers' stocks increased from 21,111 tons to about 40,000 tons. On the basis of performances during the last few months, Government and consumers' stocks combined should increase by July 1 to the edge of 100,000 tons (exclusive of such Bolivian concentrates as will have been received by that time).

The total visible supply of tin on February 28 was 38,308 tons, against 38,584 tons on January 31, according to Mr. W. H. Gartsen (Henry Rogers, Sons & Company). The carry-over in the Straits Settlements was 3,165 (3,333) tons, while the carry-over at principal European smelters was 2,939 (2,868) tons.

Mr. C. V. Stephens, addressing the annual meeting of Southern Malayan Tin Dredging, Limited, recently, said that, in response to an appeal made by the F.M.S. Government to the mining community in July last to help the war effort by stepping up production to the maximum, the company had been engaged in producing tin on a scale which had already enabled the revenue won to date to approximate their E.P.T. standard profits. He felt sure that his listeners were only too willing that their company should support the war effort with a maximum production of tin, for the large consumption of the metal by the U.S.A. made it a valuable factor in providing currency for the purchase of war equipment from that country. Nevertheless, having already approximated their E.P.T. standard of profit, they would for the next four months be running the dredges and depleting their ore reserves for the exclusive benefit of the inland revenue. In the case of mining companies, whose business was the dealing with wasting assets and who received no allowance for amortisation of such assets, the Excess Profits Tax might truly be said to operate as a capital levy, said Mr. Stephens. In his opinion, the raising of the Excess Profits Tax to 100 per cent. was a mistake, and he felt sure that a reduction of the rate would prove both an incentive to economy and an inducement to maximum production.

Tin prices on the London Metal Exchange during the past week have been as follow:—

Cash—Thursday, £264 10s. to £265; Friday, £266 to £266 10s.; Monday, £264 to £264 10s.; Tuesday, £265 to £265 5s.; Wednesday, £266 10s. to £266 15s.

Three Months—Thursday, £262 10s. to £262 15s.; Friday, £265 15s. to £266; Monday, £263 15s. to £264; Tuesday, £264 to £264 10s.; Wednesday, £266 5s. to £266 10s.

Copper—In the United Kingdom, copper consumers on Government priority lists are satisfactorily placed with regard to supplies, but the position of the non-essential user remains somewhat difficult. American demands for copper during the present year may be expected to absorb the bulk of the Latin-American output. Congo metal is being placed at the disposal of Great Britain, so that it would seem that Japan will experience ever-increasing difficulties in getting her needs covered, while shipments to the Soviet Union (and, perhaps, indirectly to Germany) are likely to be on a much lower scale than in normal times.

Spelter—Busy conditions prevail among consuming interests, and available supplies are largely reserved for works operating on Government orders. Steps have been announced to expand the production of zinc in the United States, where efforts are being made to obviate the need for the introduction of an official priority system for the distribution of supplies. In this respect smelters have agreed to refrain from selling on the Commodity Exchange except to close out long positions.

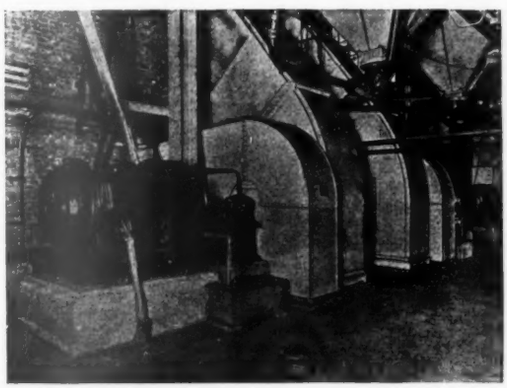
Lead—While rather slack conditions are apparent in several lead-consuming trades, demand from cable and battery manufacturers is strong.

Reliability . . .

Many are the ways by which we defend our island nation against aggression, but first and foremost among our fighting services comes the Royal Navy, whose exploits in the present conflict uphold a high tradition of reliability, of courage and endurance reaching the peak of human endeavour.

Reliability is also traditional with the manufacture of **"SIROCCO" MECHANICAL DRAFT FANS,** and **"DAVIDSON" CENTRIFUGAL FLUE DUST COLLECTORS.** "Sirocco" Fans are fulfilling efficient service in Foundries and similar applications, while "Davidson" Collectors[3] are recognised as the pre-eminent plant for prevention of grit emission from boiler and furnace chimneys.

Send for Publications SF299 and SF66 describing these Products and their various applications in industry.



The illustration on the left shows an installation of "Sirocco" Mechanical Draft Equipment in a large engineering concern.

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BELFAST —— NORTHERN IRELAND.

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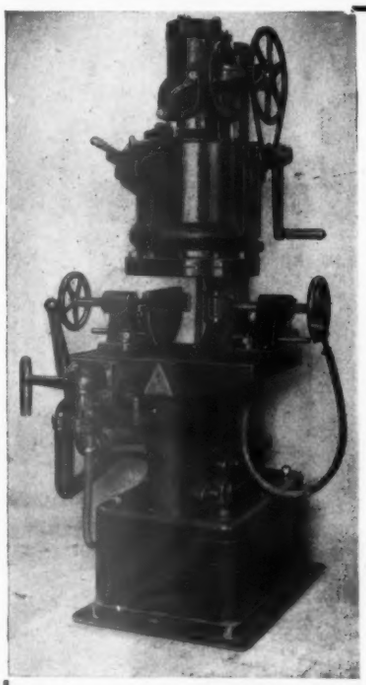

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increase production tenfold as compared with hand methods and achieve better quality at 15% of the former cost.

Sand Wizard
Airless Sandblast Machines effect definite savings of 80% with a minimum labour economy of 65%

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RAW MATERIALS—PRICE LIST

Wednesday, March 5, 1941

COPPER*

	£	s.	d.
Electrolytic	62	0	0
High-grade fire-refined ..	61	10	0
Fire-refined or not less than 99.7 per cent.	61	0	0
Do., do., 99.2 per cent. ..	60	10	0
Black hot-rolled wire rods..	65	10	0

TIN

Standard cash	266	10	0
Three months	266	5	0
Settlement..	266	10	0
Official average Cash, Feb.	265	3	10½
Do. Three Months, Feb.	263	19	7½
Do. Settlement, Feb. ..	265	2	9

SPELTER*

G.O.B. (foreign) (duty paid)	25	15	0
Do. (domestic)	26	10	0
" Prime Western " ..	26	10	0
Refined and electrolytic ..	27	5	0
Not less than 99.99 per cent.	28	15	0

LEAD*

Good soft pig lead (foreign) (duty paid)	25	0	0
Do., do., (Empire and domestic)	25	0	0
English	26	10	0
Sheets, home	34	10	0
Do. export, f.o.b. ..	31	0	0
Pipes, home	34	0	0
Do. export, f.o.b. ..	31	10	0
Tea lead (nom.)	—		

ALUMINIUM

Ingots	£110
Wire, 10g.	nom.
Sheets	nom.
Circles, 20/24g.	nom.

ZINC SHEETS, etc.

	£	s.	d.
Sheets, 10g. and thicker, ex works..	39	2	6
Rolled zinc (boiler plates), ex works..	37	2	6
Zinc oxide (Red Seal), d/d buyers' premises ..	28	7	6

ANTIMONY

English, 99%, delivered ..	85	0	0
Foreign Regulus, duty paid .. 88 0 0 to	91	0	0
Chinese, prompt shipment, c.i.f. .. 76 0 0 to	80	0	0

QUICKSILVER

Quicksilver, ex-w'hse London	49	0	0

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten 3s. 0d.
Finished bars, 18% tungsten 3s. 10d.
Finished bars, 22% tungsten 4s. 4d.
Per lb. d/d buyers' works.

NICKEL SILVER, etc.

	Per lb.
Ingots for raising ..	10d. to 1/4
Rolled—	
To 9 in. wide ..	1/4 to 1/10
To 12 in. wide ..	1/4½ to 1/10½
To 15 in. wide ..	1/4½ to 1/10½
To 18 in. wide ..	1/5 to 1/11
To 21 in. wide ..	1/5½ to 1/11½
To 25 in. wide ..	1/6 to 2/–
Ingots for spoons and forks	10d. to 1/6½
Ingots rolled to spoon size	1/1 to 1/9½
Wire round—	
to 10g.	1/7½ to 2/2½

with extras according to gauge.

Special 5ths quality turning rods in straight lengths, 1/6½ upwards.

* Maximum prices per long ton delivered to buyers' premises.

FERRO-ALLOYS AND STEEL-MAKING METALS

	£	s.	d.
Ferro-silicon (5-ton lots)—			
25%	21	0	0
45%	23	10	0
75%	36	10	0
Ferro-vanadium—			
35/50%	15/3 lb. Va.		
Ferro-molybdenum—			
70/75% carbon-free ..	6/– lb. Mo.		
Ferro-titanium—			
20/25% carbon-free ..	1/9 lb.		
Ferro-tungsten—			
80/85%	5/1 lb.		
Tungsten metal powder—			
98/99%	5/2¼ lb.		
Ferro-chrome—			
2/4% car.	—		
4/6% car.	47	0	0
6/8% car.	47	0	0
8/10% car.	—		
Ferro-chrome—			
Max. 2% car.	1/0¾ lb.		
Max. 1% car.	1/1½ lb.		
Max. 0.5% car... ..	1/1¾ lb.		
70% carbon-free ..	—		
Nickel—99.5/100%	£190 to £195		
"F" nickel shot	175	0	0
Ferro-cobalt, 98/99% ..	8/9 lb.		
Metallic chromium—			
96/98%	3/9 lb.		
Ferro-manganese—			
76/80% loose	18	10	0
76/80% packed	20	0	0
Metallic manganese—			
94/96% carbon-free ..	1/9 lb.		

Per ton unless otherwise stated, basis 2-ton lots, d/d Sheffield works.

SCRAP*

	£	s.	d.	£	s.	d.
SOUTH WALES—						
Short heavy steel, not ex. 24-in. lengths.. ..	4	2	0	to 4	4	6
Heavy machinery cast iron				4	7	0
Ordinary heavy cast iron				4	2	0
Cast-iron railway chairs				4	7	0
Medium cast iron ..				3	18	3
Light cast iron				3	13	6
MIDDLESBROUGH—						
Short heavy steel	3	19	9	to 4	2	3
Heavy machinery cast iron				4	11	9
Ordinary heavy cast iron				4	9	3
Cast-iron railway chairs				4	9	3
Medium cast iron ..				3	19	6
Light cast iron				3	14	6
BIRMINGHAM DISTRICT—						
Short heavy steel	3	14	9	to 3	17	2
Heavy machinery cast iron				4	12	3
Ordinary heavy cast iron				4	7	6
Cast-iron railway chairs				4	7	6
Medium cast iron ..				4	0	3
Light cast iron				3	15	3
SCOTLAND—						
Short heavy steel	3	19	6	to 4	2	0
Heavy machinery cast iron				4	14	3
Ordinary heavy cast iron				4	9	3
Cast-iron railway chairs				4	14	3
Medium cast iron ..				3	17	3
Light cast iron				3	12	3

* Delivered free to consumers' works in England and Wales. For deliveries of cast-iron scrap free to consumers' works in Scotland, the above prices less 3s. per ton, but plus actual cost of transport or 6s. per ton, whichever is the less. All prices: Plus 2½ per cent. dealers' remuneration: 50 tons and upwards over three months 2s. 6d. extra.

PIG-IRON*

N.E. COAST (d/d Tees-side area)—	
Foundry No. 1	131/–
" No. 3	128/–
" No. 4	127/–
Forge No. 4	127/–
Hematite No. 1	138/6
Hematite M/Nos.	138/–
N.W. COAST—	
Hem. M/Nos. d/d Glasgow	138/6
" d/d Birmingham ..	150/–
MIDLANDS (d/d Birmingham dist.)—	
Staffs No. 4 forge	129/–
" No. 3 fdry.	130/–
Northants forge	126/6
" fdry. No. 3 ..	127/6
" fdry. No. 1 ..	130/6
Derbyshire forge	129/–
" fdry. No. 3 ..	130/–
" fdry. No. 1 ..	133/–
Phosphorus 0.5% to 0.75%	137/6
Phosphorus 0.1% to 0.5%	140/6
SCOTLAND—	
Foundry No. 1, Grangemouth	127/3
" No. 3, Grangemouth	124/9
Cleveland No. 3, Glasgow	131/–
" " Falkirk ..	128/–
Scottish hem. M/Nos. d/d..	138/6
SHEFFIELD (d/d district)—	
Derby forge	126/6
" fdry. No. 3	127/6
Lincs forge	126/6
" fdry. No. 3 ..	127/6
W.C. hematite	144/–
LANCASHIRE (d/d eq. Man.)—	
Derby fdry. No. 3.. ..	133/–
Staffs fdry. No. 3	133/–
Northants fdry. No. 3 ..	131/6
Cleveland fdry. No. 3 ..	133/–
Cylinder and Refined Irons	
North Zone..	174/–
South Zone..	176/6
Refined Malleable	
Birmingham and S. Staffs	171/6
Cold Blast	
South Staffs	220/6

* Prices of hematite and basic pig-iron, and of foundry and forge iron with a phosphoric content of not less than 0.75 per cent., are subject to a rebate of 5s. per ton under certain conditions.

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms and Slabs.

BASIC:	£	s.	d.
Soft, u.t.. 100-ton lots ..	12	5	0
Tested, up to 0.25% C. ..	12	10	0
Tested, 0.25 to 0.33% C.	12	12	6
Tested, 0.33 to 0.41% C...	12	15	0
Hard (0.42 to 0.60% C.)..	13	17	6
" (0.61 to 0.85% C.)..	14	7	6
" (0.86 to 0.99% C.)..	14	17	6
" (1% C. and up) ..	15	7	6
Silico-manganese ..	16	5	0
Free-cutting	14	10	0
SIEMENS MARTIN ACID			
Up to 0.25% C.	15	15	0
Case-hardening	16	12	6
Silico-manganese	16	5	0

Billets, Blooms and Slabs for Forging and Stamping.

Basic soft, up to 0.25% C. ..	13	17	6
Basic hard, 0.41 to 0.60% C.	14	10	0
Acid, up to 0.25% C. ..	16	5	0

Other Semi-products, etc.

Tin bars	12	2	6
Sheet bars	12	2	6
*Wire rods, soft basic ..	17	7	6
" hard basic ..	21	2	6
" free-cutting ..	20	2	6
" acid	24	13	6

* Subject to rebate

FINISHED STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel bars, sections plates, joists and hoops is obtainable in the home trade under certain conditions.]

	£	s.	d.
Plates, ship (N.E. Coast) ..	16	3	0
Boiler plts. (N.E. Coast) ..	17	0	6
Chequer plts. (N.E. Coast)	17	13	0
Angles, over 4 un. ins. ..	15	8	0
Tees, over 4 un. ins. ..	16	8	0
Joists, 3 in. × 3 in. and up	15	8	0
Rounds and squares, 3 in. to 5½ in.	16	8	0
Rounds under 3 in. to ¾ in. (untested)	17	12	6
Flats—over 5 in. wide ..	15	13	0
" 5 in. wide and under ..	17	12	0
Rails, heavy, f.o.t. ..	14	10	6
Hoops	18	7	0
Black sheets, 24 g. (4 t. lots)	22	15	0
Galv. cor. shts. (")	26	2	6
Galv. flat shts. (")	26	12	6
Galv. fencing wire, 8g. plain	26	17	6

FINISHED IRON

	£	s.	d.
CROWN IRON:			
England and Wales ..	15	12	6
Scotland	15	12	6
Ireland, f.o.q.	16	5	0
No. 3 BARS:			
England and Wales ..	12	10	0
Scotland	13	12	6
Ireland, f.o.q.	13	2	6
No. 4 BARS:			
England and Wales ..	13	0	0
Scotland	13	17	6
Ireland, f.o.q.	13	12	6
STRIP:			
England and Wales ..	17	0	0
STAFFS MARKED BARS, f.o.t...	18	10	0

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated, January 21, 1941

	Dols.
No. 2 foundry, Phila.	25.84
No. 2 foundry, Valley	24.00
No. 2 foundry, Birm.	19.38
Basic, Valley	23.50
Malleable, Valley..	24.00
Grey forge, Valley	24.50
Ferro-mang., seaboard	120.00
O.-h. rails, h'y, at mill	40.00
Billets	34.00
Sheet bars	34.00
	Cents
Iron bars, Chicago	2.25
Steel bars	2.15
Tank plates	2.10
Beams, etc.	2.10
Wire rods	2.00
Skelp, grooved steel	1.90
Steel strip	2.10
Steel sheets	2.10
Sheets, galv., 24 g.	3.50
Wire nails	2.55
Plain wire	2.60
Tinplates, 100-lb. box	$5.00

COKE (at ovens)

(nominal)

Welsh foundry	47/6 to 49/–
" furnace	35/6 to 37/–
Durham foundry	45/6
" furnace	35/6
Scottish foundry	46/– to 51/–
" furnace	35/6

TINPLATES

(f.o.b Bristol Channel ports)

I.C. cokes	20 × 14 per box	30/9 to 31/9
"	28 × 20 "	61/6 to 63/6
"	20 × 10 "	44/3 to 44/9
"	18¾ × 14 "	32/– to 32/6
C.W.	20 × 14 "	27/9 to 28/9
"	28 × 20 "	55/6 to 57/6
"	20 × 10 "	42/3 to 42/9
"	18¾ × 14 "	30/– to 30/6

NON-FERROUS SCRAP

(Official Maximum Prices, per ton ex Works.)

	£	s.	d.
Bright untinned copper wire, in crucible form or in hanks	57	10	0
No. 1 copper wire	57	0	0
No. 2 copper wire	55	10	0
Copper firebox plates, cut up	57	10	0
Clear untinned copper, cut up	56	10	0
Braziery copper	53	10	0
Q.F. process and shell-case brass, 70/30 quality, free from primers	49	0	0
Clean fired 303 S.A. cartridge cases	47	0	0
70/30 turnings, clean and baled	43	0	0
Brass swarf, clean, free from iron and commercially dry	34	10	0
New brass rod ends, 60/40 quality	38	10	0
Hot stampings and fuse metal, 60/40 quality	38	10	0
Admiralty gunmetal, 88-10-2, containing not more than ½ per cent. lead or 3 per cent. zinc, or less than 9½ per cent. tin	72	0	0

NEW BRASS TUBES, etc.

	Per lb.
Solid drawn tubes	13¾d.
Brazed tubes	15½d.
Rods, drawn	11½d.
Rods, extd. or rlld.	8¾d.
Sheets to 10 w.g.	10½d.
Wire	10¾d.
Rolled metal	10d.
Yellow metal rods	8¼d.

COPPER TUBES, etc.

Solid drawn tubes	15d.
Brazed tubes	15d.
Wire	9¾d.

PHOSPHOR BRONZE

	Per lb. basis
Strip	13½d.
Sheet to 10 w.g.	14½d.
Wire	15½d.
Rods	15½d.
Tubes	21d.
Castings	17d.

Delivery 3 cwt. free.
10% phos. cop. £35 above B.S.
15% phos. cop. £40 above B.S.
Phosphor tin (5%) £40 above price of English ingots.

C. CLIFFORD & SON, LIMITED.

AVERAGE PRICES OF GALVANISED CORRUGATED SHEETS (NORTH OF ENGLAND)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1910	11 15 0	12 5 0	12 5 0	11 15 0	11 10 0	11 10 0	11 12 6	11 12 6	11 12 6	11 12 6	11 10 0	11 10 0	11 13 4
1911	11 5 0	11 1 3	10 15 0	10 15 0	10 13 9	10 10 0	10 13 9	11 0 0	11 5 0	11 5 0	11 5 0	11 7 0	10 19 7½
1912	11 10 0	11 10 0	11 10 0	11 15 0	12 5 0	12 5 0	12 5 0	12 5 0	12 5 0	12 12 6	12 18 0	12 15 0	12 2 11½
1913	12 15 0	12 15 0	12 15 0	12 11 3	11 18 0	11 15 0	11 15 0	11 15 0	11 15 0	11 3 0	11 0 0	11 2 6	11 13 4
1914	11 7 0	11 7 6	11 7 6	11 5 7½	11 2 6	10 15 0	10 15 0	12 17 6	14 2 0	13 7 0	11 15 7	11 2 6	11 16 0
1915	11 10 8½	13 12 6	14 8 9	15 0 6	17 17 6	20 17 6	20 17 6	20 6 3	17 12 6	18 1 0	22 13 9	25 2 0	18 3 4½
1916	26 5 0	27 12 6	28 0 0	28 5 0	29 0 0	29 0 0	28 15 0	28 3 0	28 15 0	28 15 0	28 15 0	28 15 0	28 6 8½
1917	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 0 0	28 0 0	28 0 0	28 11 2
1918	28 5 0	28 15 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	28 13 4
1919	29 0 0	29 0 0	29 0 0	28 0 0	28 10 0	27 7 6	27 5 0	29 3 0	32 0 0	33 0 0	36 10 0	40 8 4	31 5 3½
1920	46 10 0	49 15 0	53 15 0	56 0 0	⅝ 10 0	54 10 0	52 10 0	48 10 0	44 3 4	39 2 6	35 17 6	30 8 0	47 4 3
1921	28 10 0	25 17 6	24 5 0	23 3 4	22 0 0	22 0 0	23 10 0	21 12 6	20 0 0	18 15 0	18 3 9	17 2 0	22 1 7
1922	16 17 6	15 13 9	16 3 0	16 10 0	16 4 4½	15 15 6	15 16 3	16 16 0	16 8 9	16 6 3	17 1 0	17 7 6	16 7 8½
1923	18 3 1½	19 1 11½	19 8 0	19 10 0	19 7 0	19 1 3	18 0 0	18 13 1½	19 0 0	19 2 9	19 2 6	18 19 4½	18 19 2
1924	18 13 6	18 9 4½	18 5 0	17 15 11½	17 3 0	17 19 4½	18 7 6	18 8 1½	18 8 1½	17 19 6	17 11 3	17 10 0	18 0 10½
1925	17 8 6	17 1 6½	16 9 4½	16 12 0	16 9 8½	16 9 4½	16 0 6	16 1 10½	16 5 0	16 7 0	16 12 6	6 15 0	16 11 0½
1926	16 14 4½	16 5 7½	16 0 6	15 11 10½	15 11 3	16 0 0	16 16 0	16 18 9	16 14 0	16 18 9	17 10 0	6 19 0	16 10 0½
1927	16 3 1	15 7 6	15 3 3	15 3 1½	14 14 4½	14 11 4	14 1 10½	14 0 0	13 19 6	13 16 10½	13 13 1½	13 3 9	14 9 10
1928	13 0 0½	13 2 6	13 6 0	13 2 6	13 3 0	13 6 9	13 11 3	13 10 0	13 10 7½	13 12 6	13 11 6	13 10 0	13 8 8½
1929	13 11 0	13 13 1½	13 12 9½	13 10 11½	13 9 3	13 8 9	13 11 6	13 7 6	13 7 6	13 5 6	12 18 9	12 12 9½	13 7 5½
1930	12 5 0	11 15 0	11 19 6	11 18 7	11 18 0	11 17 6	11 17 6	11 17 6	11 16 3	11 12 6	11 8 9	11 5 0	11 15 11½
1931	11 4 0	11 0 0	11 0 0	11 0 0	10 13 9	9 18 9	9 13 0	9 5 3½	8 19 0½	9 16 0	9 8 9	9 4 0½	10 1 10½
1932	9 2 9	9 14 4½	9 16 0	9 13 9	9 12 6	9 12 6	9 11 0	9 4 4½	9 11 3	10 12 6	11 5 0	11 7 0	9 18 7
1933	11 15 0	11 15 0	11 15 0	11 15 0	11 17 8	12 4 0	12 10 0	12 10 0	12 12 6	12 15 0	12 15 0	12 15 0	12 4 11
1934	12 15 0	12 15 0	12 15 0	12 17 6	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	12 18 6½
1935	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 2 6	13 5 0	13 7 6	13 1 3
1936	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 14 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	13 14 5
1937	14 0 0	14 0 0	15 10 0	17 0 0	19 10 0	19 10 0	19 10 0	19 10 0	19 10 0	19 10 0	19 10 0	19 7 0	18 0 7
1938	18 10 0	18 10 0	18 10 0	18 10 0	18 10 0	18 10 0	18 10 0	18 10 0	18 10 0	18 10 0	18 10 0	18 10 0	18 10 0
1939	17 5 0	17 5 0	17 5 0	17 5 0	17 5 0	17 5 0	17 5 0	17 5 0	17 5 0	17 5 0	18 12 6	18 12 6	17 9 7
1940	18 12 6	20 0 0	20 0 0	20 13 0	20 16 3	20 16 3	22 12 6	22 12 6	22 12 6	22 12 6	26 2 6	26 2 6	21 2 0
1941	26 2 6	26 2 6	—	—	—	—	—	—	—	—	—	—	—

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CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.
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All grades FOUNDRY, HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

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(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED

ASSISTANT Foundry Manager seeks advancement (age 30). Non-ferrous, aluminium, high lead bronzes, copper lead lining. Mechanical plant. Competent organiser. —Box 668, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

FOUNDRY MANAGER required for Grey Iron Foundry. Jobbing and repetition castings. Practical experience and keen organiser essential. State full particulars of experience, references, age, wages, etc.—Apply, Box 666, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

WANTED.—A man with good knowledge of chemistry and metallurgy, to take charge of an electric steel-melting plant in the North Riding of Yorkshire.—Apply in writing, Box 662, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

EMPLOYMENT REGISTER.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

MANAGER for Foundry Trade. Over 30 years' experience light general and electrical castings. Foundry, patternshop, drawing office, machine shop, sales experience. (402)

FOUNDRY MANAGER or Assistant, 27 years' experience in general jobbing and repetition grey-iron castings. Capable to take complete control. First-class practical and technical experience in foundry, core-shop, cupola control, etc. Good metallurgical knowledge. Aged 40. (403)

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GENTLEMAN able to influence business in repetition light castings is prepared to join board of firm of ironfounders short of work owing to war, on terms to be agreed. Advertiser is director of similar company working to maximum capacity.—Replies, treated with strictest confidence, to Box 664, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

AGENCY

WELL-ESTABLISHED firm in Midlands, with close connection with all leading engineering, industrial and aeronautical foundries, requires additional representation for foundry plant or supplies. Excellent references can be given. Energetic and technical service assured by practical and experienced staff.—Box 660, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

PROPERTY

IRON and Brass Foundry to let, adjoining engineering works. 1,000 tons p.a. part output assured.—WHEAWILL & SUDWORTH, Accountants, Westgate, Huddersfield.

MACHINERY

SAND MIXERS AND AERATORS.—The "Breakir" Centrifugal Machine is *THE* machine. Outputs 10 cwts. to 8 tons per hr.—W. BREALEY & CO. LTD., Station Works, Ecclesfield, Sheffield.

MACHINERY—*Continued*

NEW Dwarf Cupola, to melt 10 to 15 cwts. per hour; New Worm-geared Ladles, 4-tons, 2-tons, 30-cwts., 20-cwts., 15-cwts. and 10-cwts. capacity; also Osborn Cupola Spark Arresters.—T. DAVIES & SON, West Gorton, Manchester, 12.

THOS. W. WARD, LTD.

39-in. Swing HEAVY DUTY VERTICAL DRILLING AND TAPPING MACHINE (Butler), 2¼ in. dia. spindle No. 6 M.T., having 17¼ in. feed; 3 in. drilling capacity; fast and loose pulley through gearbox drive.

4-ft. 6-in. Swing Low Base RADIAL DRILLING MACHINE, also tapping; No. 4 M.T. spindle with 14 in. travel; arranged for single pulley drive through gearbox.

4-ft. Swing Box Bed RADIAL DRILLING AND TAPPING MACHINE (Kendall & Gent); 2¼ in. dia. spindle No. 4 M.T.; separate tapping spindle, having 8 in. feed.

2-ft. 6-in. Swing RADIAL DRILLING AND TAPPING MACHINE (Archdale); 1¾ in. dia. spindle No. 4 M.T. with approx. 9 in. feed; 4-step cone drive back geared.

Write for "Albion" Catalogue.

ALBION WORKS, SHEFFIELD

'Grams: "Forward." 'Phone: 26311 (15 lines).

FOR SALE.—One Junior Motive Type Sand-slinger, built by the Foundry Plant & Machinery, Ltd., and only recently put into work. Travelling type with 7-tons sand bin with 12-ft. radius arm. The machine is complete and in first-class condition. Can be seen by appointment.—SIR JAMES FARMER NORTON & CO., LTD., Adelphi Iron Works, Salford 3, Manchester.

PNEUMATIC MOULDING MACHINES

Macdonald Jolter, table 72 in. by 54 in.

Tabor ditto, table 27 in. by 20 in.

Tabor 21 in. by 16 in. squeeze.

Zimmerman Type R.P.W. 2 Jolt Squeeze turnover, table 36 in. by 20 in.

Mumford Type (Jackman) Swing Headpress, 13 in. by 15 in. and 14 in. by 16 in.

Mumford Pneumatic Core Jolters having 15-in. by 20-in. and 12-in. by 12-in. tables.

Britannia No. 1 "Coventry" Pneumatic Turnover Jarr Ram, table 30 in. by 28 in.

50 Air Compressors; 500 Electric Motors, Dynamos, etc.

S. C. BILSBY, A.M.I.C.E., A.M.I.E.E.
CROSSWELLS ROAD, LANGLEY,
Nr. Birmingham.
'Phone: Broadwell 1359.

MISCELLANEOUS

PATTERNS IN WOOD AND METAL for all branches of Engineering. Moulding methods carefully considered.—FURMSTON & LAWLOR, Letchworth.

FURNACE CAPACITY

available for all kinds of Heat Treatment in large Muffle Chambers at temperatures up to 950° Centigrade.

NATIONAL ENAMELS LIMITED,
53, Norman Road, Greenwich,
London. S.E.10

MISCELLANEOUS—*Continued*

ACCURACY PATTERN CO., Havannah Street, Congleton, Ches., undertake Engineers' Patternmaking Requirements to finest limits with due consideration to elimination of foundry production difficulties.

'Phone: 22877 SLOUGH

Modern 48" Cupola, complete with blower, motor hoist and staging for prompt disposal; lying at Manchester; space wanted.

2 Morgan 250 lbs. Tilting Furnaces Oilfired.

NEW PIT FURNACES 150 lbs. capacity, oil or coke fired. £35 each.

NEW SHOT BLAST CABINET PLANTS with motor driven Exhaust Fans, complete, all sizes. Prompt delivery.

Modern 60" Jackman Sand last Table.

Augusts No. 1 intensive sandmixer.

ALEX. HAMMOND, *Foundry Machinery Merchants.*
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BUY FROM ME AND SAVE MONEY.

STEEL GRIT ROUND & ANGULAR
FOR SHOT BLASTING.
Prompt Deliveries at Controlled Prices.
MOWAT'S PIONEER GRIT CO. LIMITED.
HOLLAND STREET, ABERDEEN

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The Standard work of reference covering the Coal, Iron, Steel, Tinplate, Metal, Engineering, Hardware and Allied Trades.

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